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THE ROLE OF FLUORIDE IN PUBLIC HEALTH. THE SOUNDNESS OF FLUORIDATION OF COMMUNAL WATER SUPPLIES. A SELECTED BIBLIOGRAPHY

Irene R. Campbell

Cincinnati University
Cincinnati, Ohio

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THE ROLE OF FLUORIDE IN PUBLIC HEALTH

The Soundness of Fluoridation of Communal Water Supplies

A Selected Bibliography

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1963

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PREFACE

This book has been prepared for people who have reason to be concerned in the fluoridation of water. Publications have been selected from a large volume of literature on the basis of providing information on the soundness of fluoridation, and of their usefulness to community leaders and others who have the responsibility of public water supplies.

No element which occurs naturally in the environment of man, and therefore in trace amounts in his tissues, has had so much attention in the scientific and in the popular literature in the past thirty years as has fluorine. No other element has been investigated so thoroughly, in relation to human dental health, epidemiologically, and clinically in regions where it occurs naturally in the drinking water or where it has been added to fluoride-deficient waters. Moreover, few elements have been examined so extensively in relation to human health generally in industries using fluorides, or for their effects upon animals under field conditions or in the experimental laboratory, or with regard to their behavior in isolated organ systems and in artificial media (in vitro) as well as on plants and micro-organisms. The growth of the literature concerning fluorine and its compounds has not been confined to biological fields, for these compounds have found extensive technologic usage in industry, in agriculture, and in the atomic energy and space programs. It is not surprising that by this time a tremendous volume of publications on this group of compounds has appeared, and continues to grow.

The Kettering Laboratory became interested in the fluoride literature in the late 1920's with its investigation of the physiological effects of some of the "Freons" (a class of organic fluorides now in widespread use) from the point of view of public health. These compounds were then being developed as refrigerants, and their safety under usual circumstances or under the most unfavorable conditions was being investigated in governmental and other laboratories. As a result of subsequent studies of the effects and metabolism — behavior in the human and animal organism — of the inorganic fluorides, especially of hydrogen fluoride which may be liberated when Freon comes in direct contact with a flame, the Kettering Laboratory was requested to investigate numerous other features of environmental hygiene involving the inorganic fluorides in the laboratory, in industry, and in the community.

In view of the growing literature on this group of compounds, particularly the inorganic, a systematic bibliographic program was initiated at the Kettering Laboratory in the late 1940's at the request of several sponsors,* whose concern was the effect of industrial exposure to fluorides. This resulted in the publication in 1958 of an annotated bibliography, "The Occurrence and Biological Effects of Fluorine Compounds. Volume I. The Inorganic Compounds," containing approximately 8700 abstracts. The review of the literature has continued since the appearance of that publication, and the work at present is supported by a grant from the National Institute of Dental Research.

The bibliographic program is limited to the collection of material concerning the biological aspects and those of environmental (or public) health, including the natural and man-made occurrence of fluorides, the control of potentially hazardous environmental conditions, and the required analytical methods. Only the literature as covered by the medical and scientific abstracting and indexing services (Index Medicus, Chemical Abstracts, and others), and by those of the legal and social sciences, is included, as are reports of governmental, national and international health organizations, and of universities.

An important phase of the present work is the preparation and issuance of abstracts of selected reliable and critically evaluated publications pertaining to the fluorides that would be of interest and value to people who are interested in the fluoridation of communal water supplies. A compilation of the entire extensive literature on the subject would be of little assistance to those who are concerned with the welfare of their community, not only because of the number of publications, but because the scientific reliability of some is highly questionable. This is true of any literature concerning environmental health, which often provokes controversy. An evaluation by competent people of the literature pertaining to biological processes, and particularly the biological response to chemical or physical agents in the environment, is therefore necessary.

The abstracts (or digests of the publications) included in this bibliography, which will be supplemented periodically, were selected with the assistance of an Advisory Editorial Board consisting of members who have themselves investigated and followed the physiology and pharmacology of fluorides, and their effects on dental health, and those who have been concerned with the educational, legal, engineering, and chemical matters. The first compilation considers the literature through 1962 and is designed to establish the basic principles of the role of fluoride in dental health, and of the soundness of the use of water containing fluoride at a concentration of one part per one million parts (1 ppm) of water. The references are limited to those concerning the inorganic compounds, since the fluoride ion exists chiefly as such. (Two organic compounds, fluoroacetate and a fluoro-oleic acid, are known to occur naturally in a genus of plants, but their action or that of any other organic compound containing fluorine is not due to the fluoride ion per se.)

The abstracts have been arranged first by several broad categories, according to primary subject matter of the publication. Within the individual sections, the arrangement is generally chronologic, historically or according to date of publication, or by related material. There are cross-references at the end of each of these sections to related references placed in the others. Each of the sections is introduced briefly to explain the scope of coverage, and to point out certain special factors applying to the subject. In most cases, the abstracts have been designed to provide specific information. Some references that need to be consulted in the original, such as books, reviews, and the question-and-answer type of compilations, have been abstracted briefly to indicate the nature of their contents.

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* Aluminum Company of America, Aluminum Company of Canada, Ltd., American Petroleum Institute, Columbia-Geneva Steel Company, E. I. DuPont de Nemours, Harshaw Chemical Company, Kaiser Aluminum and Chemicals Corporation, Minnesota Mining and Manufacturing Company, Pennsylvania Salt Manufacturing Company, Reynolds Metals Company, Tennessee Valley Authority, and the Universal Oil Products Company.

The comprehensive literature pertaining to the occurrence of fluorides in the environment, animal experimentation, and analytical methods, is especially voluminous. In this bibliography, references in these areas have been limited to reviews, extensive compilations, or significant recent findings. Observations in vitro or on isolated organs, especially as applied to effects on enzymes are represented by only one reference (Abstract No. 20). The fluorides are one among many groups of compounds that have been and continue to be used in the study of the presence, or activity, of enzyme systems in animal and human tissues. Most of the observations have been made on artificial media or isolated organs and the concentrations of the compounds employed generally have not been of the order of magnitude of those that occur in the tissue or fluids of intact animals or of man under conditions of usual absorption, nor do the media employed for their study represent the actual conditions of living tissue.

Fluoride is one of many ions belonging to the "trace elements" that occur in the universe, and that are taken in by man and animals from foods, water and air, absorbed into the tissues, utilized and retained there in variable concentrations, depending on the quantities ingested and inhaled, and then eliminated from the body. Ideally, the intake of all of these elements is limited to concentrations consistent with good health. In the case of some, insufficient intake results in a disturbance of bodily function; in the case of all, quantities in excess of the tolerated range are harmful to one system or another. In certain disease states, the quantities deposited in the tissues may vary from the "normal" ranges, even without unusual exposure.

The quantitative aspects of intake and of elimination are therefore of paramount importance in the evaluation of the effects, beneficial or harmful, induced by any substance. For this reason, care has been taken to include in the abstracts sufficient detail to reveal the degree of thoroughness of an investigation. It is essential also to know the reliability of the analytical method used and the experience in these matters of the laboratory undertaking the investigation. In viewing analytical results, it is also important to know whether the analytical findings refer to fresh tissue or other materials, or whether the material had been reduced to the dry or ashed state before analysis. Differences of this kind may be calculated with the aid of the GLOSSARY, where various explanations and conversions of quantitative weights and measures are given, so that the user of the bibliography may interpret and compare the results with values in more familiar terms.

The members of the Advisory Editorial Board, who represent the medical, dental, biochemical, pharmacologic or toxicologic, legal, environmental, analytical and chemical, as well as the lay aspects of fluoridation, review all abstracts selected for these bibliographies. In some cases, for clearer understanding of the work reported, comments by the Board follow the abstract. Additional references contributing to a review of investigations are appended under the "Abstractor's Note."

A continuing file of informative abstracts of the comprehensive scientific literature of the biological aspects of the fluorides, which includes of course the natural occurrence and analytical methods, is maintained by the Division of Bibliographic Research of the Kettering Laboratory.* The articles are seen in the original, copies of which are secured wherever possible. This assures awareness by the members of the Board of all reports of investigations, discussions, and reviews appearing in the world-wide literature.

The author is assisted by Irene P. Kukainis in the abstracting and details of the work. The assistance, as the need arises, of other members of the staff, Evelyn M. Widner, Lilli Lange, Adelaide B. Badgley, Erela Meiri, and Lorraine Borchelt, is gratefully acknowledged.

*The abstract card file of the comprehensive bibliography is available to libraries of health departments and of interested research organizations at a nominal annual subscription fee, as a self-sustaining service. Copies of the bibliography published in 1958 are also available from the Division of Bibliographic Research, Kettering Laboratory, College of Medicine, Eden Avenue, Cincinnati 19, Ohio.

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1. BOOKS AND GENERAL REVIEWS

No listing of books or general reviews concerning the compounds of fluorine would be considered adequate if it did not include the classic work of Kaj Roholm, "Fluorine Intoxication" (published by Lewis and Company of London in 1937). In addition to a detailed description of his own investigations among workers of the cryolite industry in Denmark (see Abstract No. 65) and experimental observations of several species of animals to whom he fed diets high in fluoride, Roholm included in his book an extensive and critical review of the literature of the action of fluorides in vitro, on lower organisms, on plants, animals and man, as well as the various uses of these compounds. This review, although most significant in its contribution to the understanding of the action of relatively high concentrations of fluorides on the various organ systems, contributes only to a limited extent to an appreciation of the metabolism and action of fluoride when it is present in water and food within the range of its effectiveness in the prevention of dental decay.

Fluorides have been known to exist in minerals and to be used industrially for centuries, and their presence in plants, animal and human tissues has been recognized for 160 years. Yet only since about 1933 have methods for the analysis of the fluoride ion in biological materials and in waters become accurate enough to determine the more exact concentrations in tissues and to define its behavior in the organism. Its beneficial effect on dental tissue was conclusively proved by Dean and his associates in 1938, although suggested by others much earlier.

There is no need to list the earlier reviews, for they are adequately covered in the more recent ones. The selection has been limited to a few works that encompass numerous aspects as represented in the various sections of this bibliography, and that are readily available in public libraries. Some of the articles or chapters contained in the books have been abstracted for inclusion in the other sections. Books and reviews pertaining to specific aspects are included in the appropriate sections.

Reports of committees that have evaluated the safety and effectiveness of fluoridation for the various national and international organizations, strictly speaking, constitute reviews, and their proper place may be considered to be here. However, as the primary purpose of these has been to explore the safety of fluoridation to the health of man, they are included in Section 4, "Metabolism of Fluoride in Man."

1. Moulton, F. R., Editor: FLUORINE AND DENTAL HEALTH. Washington, D. C., American Association for the Advancement of Science, 1942, 101 pp.

This first symposium of a comprehensive, systematic and documented discussion by invited eminent scientists in the field of dental science was held at the 1941 meeting of the American Association for the Advancement of Science. In the introduction, the editor points out that as a public health problem, dental fluorosis, the phenomenon and cause of which was only recently discovered, is rapidly assuming large proportions, but that an even more important problem of health is forecast by the material presented on the possible relation between fluorine and the decay of teeth.

The papers included are as follows:

"Mottled Enamel: Early History and Its Unique Features," by F. S. McKay; see Abstract No. 88.
"Geographical Distribution of Endemic Dental Fluorosis (Mottled Enamel)," by H. T. Dean
"The Chemistry of Fluorine as Related to Fluorosis," by H. V. Smith
"The Investigation of Physiological Effects by the Epidemiological Method," by H. T. Dean; see Abstract No. 90
"Experimental Dental Fluorosis," by I. Schour and M. C. Smith
"Removing the Stain from Mottled Enamel," by H. B. Younger
"Review of the Dental Fluorosis Studies at the University of Minnesota," by W. D. Armstrong
"Fluorine and Dental Caries with Special Reference to L. Acidophilus," by P. Jay
"Resume of the Fluorine-Caries Relationship," by G. J. Cox and M. M. Levin
"Fluorosis Studies at the University of Rochester," by J. F. Volker
"Mottled Enamel from the Standpoint of the Public Health Dentist (including the relation of fluorine to dental caries in Illinois)," by C. F. Deatherage.

2. Moulton, F. R., Editor: DENTAL CARIES AND FLUORINE. Washington, D. C., American Association for the Advancement of Science, 1946, 111 pp.

The following papers were presented at the September, 1944, meeting of the American Association for the Advancement of Science:

"Some General Epidemiological Considerations," by H. T. Dean
"Epidemiological Studies in the United States," by H. T. Dean; see Abstract No. 91
"Epidemiological Studies in the British Isles and India," by R. Weaver
"Fluorine and Dental Caries in South Africa," by T. Ockerse
"Epidemiological Aspects of Oral Lactobacillus Counts in Fluoride and Non-Fluoride Areas," by P. Jay and F. A. Arnold, Jr.
"Chemical Differences of Caries Susceptible and Immune Teeth and a Consideration of Food Sources of Fluorine," by W. D. Armstrong
"Experimental Caries and a Discussion of the Mechanism of Caries Inhibition by Fluorine," by H. C. Hodge and R. F. Sognnaes
"Nondental Physiological Effects of Trace Quantities of Fluorine," by F. J. McClure; see Abstract No. 29

"Topical Applications of Fluorides as a Method of Combatting Dental Caries," by B. G. Bibby
"The Possibility of Reducing Dental Caries by Increasing Fluoride Ingestion," by F. A. Arnold, Jr.
"Fluorine and the Public Water Supply," by A. Wolman.

3. Cox, G. J. (University of Pittsburgh, Pa.): FLUORINE AND DENTAL CARIES. In: National Research Council, Food and Nutrition Board: A Survey of the Literature of Dental Caries. Washington, D. C., National Academy of Sciences, National Research Council Publication 225, 1952, pp. 325-414.

This comprehensive review of the significance of fluoride in dental health begins with the discovery of fluoride in a fossilized elephant tooth by Morozzo in 1802, and subsequently from 1805 on, by Morichini and others, in human teeth and various biological tissues and fluids. The other topics reviewed and discussed in detail are: "Reaction of Fluoride with Bones and Teeth"; "Metabolism of Fluorine with Special Reference to Its Quantitative Presence in Soft Tissues and Fluids"; "Mottled Enamel with Special Reference to Dental Caries"; "Field Studies of Water-Borne Fluorides and Dental Caries"; "The Minima of Fluorine for Certain Toxic Effects"; "Some Considerations of Fluorine as a Beneficial Element"; "Fluoridization of Water"; "Posteruptive Use of Fluorides"; "Fluorine and Miscellaneous Regions with Low Caries Rates."

The conclusion is that fluoride affords a significant degree of protection against caries both by direct and indirect evidence. The fluoride level of plant and animal tissues (other than bone) commonly used as food is too low to provide sufficient fluoride for the formation of caries-resistant teeth and additional amounts of it must be added to obtain optimum conditions. If there is a common water supply, addition of fluoride to water is the simplest, safest, and most effective method. Although fluoride is transmissible by the placenta, and by the lactating breast, it is unlikely that sufficient fluoride for the formation of caries-resistant enamel normally reaches infants from this source; this has been demonstrated in regions with waters containing higher concentrations of fluoride by the lesser frequency of mottling of deciduous enamel as compared with the permanent enamel and by the lesser protection against decay of deciduous teeth.

4. Shaw, J. H., Editor: FLUORIDATION AS A PUBLIC HEALTH MEASURE. Washington, D. C., American Association for the Advancement of Science, 1954, 232 pp.

The volume includes the following papers presented at two symposia at the American Association for the Advancement of Science meetings of 1951 and 1952, and 4 additional papers, included for a reasonably complete evaluation of the knowledge of the relation of fluoride ingestion to human health:
"Résumé of Dental Benefits of Fluoride Ingestion," by Z. M. Stadt
"Acute Fluoride Poisoning and Crippling Chronic Fluorosis," by G. J. Cox
"Metabolism of Inorganic Fluorides," by E. J. Largent; see Abstract No. 24
"Some Public Health Aspects of Water Fluoridation," by H. C. Hodge and F. A. Smith; see Abstract No. 78
"Medical Aspects of Excessive Fluoride in a Water Supply: A Ten-Year Study," by N. C. Leone, M. B. Shimkin, F. A. Arnold, Jr., C. A. Stevenson, E. R. Zimmermann, P. B. Geiser, and J. E. Lieberman
"A Long-Term Medical Study of Children in a Community with a Fluoridated Water Supply," by E. R. Schlesinger, D. E. Overton, and H. C. Chase.
"The External Action of Fluorides and Other Agents on the Teeth in the Prevention of Tooth Decay," by B. G. Bibby and F. Brudevold; see Abstract No. 109
"Relative Merits of Various Fluoridation Vehicles," by R. F. Sognnaes
"Engineering Aspects of Fluoridation Installation," by O. J. Muegge
"Determination of Fluorides in Water," by J. G. Weart
"Some Chemical Aspects of Water Fluoridation," by M. S. Nichols

5. Muhler, J. C., and Hine, M. K., Editors: FLUORINE AND DENTAL HEALTH. THE PHARMACOLOGY AND TOXICOLOGY OF FLUORINE. Bloomington, Indiana University Press, 1959, 216 pp.

The papers constituting this symposium on fluoridation are as follows:
"Fluoride Toxicity," by F. A. Smith and H. C. Hodge
"A Comparison of Fluorides as They Naturally Occur and as They Are Added In Communal Fluoridation," by M. J. Wagner
"Fluoride and Enzyme Inhibition," by W. J. Frajola
"Fluoride Ingestion and Vitamin Metabolism," by J. W. Suttie and P. H. Phillips
"Relationship of Fluoride and Lipide Metabolism," by W. Buttner and D. Bixler
"Fluorides in Foods and Medicine," by G. J. Cox
"Fluorides and Periodontal Health," by A. L. Russell and C. L. White; see Abstract No. 118
"Excretion of Fluoride," by E. J. Largent
"Effects of Fluoridation on General Health as Reflected in Mortality Data," by T. L. Hagan; see Abstract No. 57
"Is Fluorine a Dietary Essential?" by J. C. Muhler
"The Legality of the Fluoridation Procedure," by B. J. Conway; see Abstract No. 121

In the last paper, "Summarization," J. C. Muhler concludes that, taken collectively, overwhelming evidence in support of the safety of communal fluoridation is provided.

6. Largent, E. J.: FLUOROSIS. THE HEALTH ASPECTS OF FLUORINE COMPOUNDS. Columbus, Ohio State University Press, 1961, 140 pp.

In Chapter 1, the natural occurrence of fluorides in the earth's crust, minerals, soils, water, tissues of animals and plants is reviewed briefly.

Chapter 2 deals with skeletal fluorosis in man, and Chapter 3, with the ingestion, inhalation, excretion, and storage of fluoride by man (see Abstracts Nos. 65, 66).

In Chapter 4, the fluoride concentration in blood and effects on enzymes are reviewed. In connection with the concentration in blood, even relatively recent analyses (F. A. Smith, Journal of Dental Research 29:596, 1950) of the blood of different persons from the same area, assumed to have had approximately the same fluoride intake, showed a wide spread of analytical results: the highest values (0. 06 to 0. 09 ppm) were at least 25 times higher than the lowest values reported (0 and 0. 004 ppm). It is apparent, therefore, that repeated analyses of a single sample, or a large number of individual samples, must be studied in order to obtain dependable information relating to the concentration of fluoride in the blood. In discussing the effects of fluoride on enzymes, it is pointed out that the experiments in vitro have utilized relatively high concentrations of fluoride, such as would not occur in vivo. Although liver esterase has been found to be inhibited by fluoride in vitro at concentrations as low as 0. 1 ppm, evidence is still lacking that inhibition would occur in vivo. This points out the need to examine enzyme levels in the plasma and erythrocytes of man for data relating to inhibition in vivo to learn whether or not any such inhibitions do occur as a result of those levels of fluoride in blood associated with certain exposures to high concentrations of fluoride in industry or in regions where high concentrations of fluoride occur naturally in drinking waters.

Chapter 5 discusses acute poisoning by fluorine compounds, which has occurred relatively rarely considering the wide use of these compounds, and has been caused accidentally, or with suicidal or homicidal intent. Burns by hydrofluoric acid are also briefly discussed.

Chapter 6 reviews briefly the effects of organic fluorides on man, principally the organic phosphates, acetates and the perfluorocarbons, the action of which, however, varies widely, ranging from nontoxic to highly toxic, and has no relation to the effect of the inorganic fluoride ion.

Dental fluorosis in man and the use of fluorides to prevent dental caries are reviewed in Chapter 7. Chapter 8 deals with chronic fluoride intoxication in animals. Livestock tolerate concentrations of fluoride in the daily ration ranging from 30 to 400 ppm, depending upon species, without injury to health. Acute poisoning in animals is discussed in Chapter 9, and fluoride damage to plants, in Chapter 10. Chemical analysis of trace quantities of fluoride is reviewed in Chapter 11.

Fluorides and occupational health are treated in Chapter 12, including the uses of fluorides in industry. It is pointed out that the health of workers is relatively easily safeguarded by periodic examinations including X rays to observe as early as possible the appearance of any increase of radiopacity of bone, but principally by periodic analysis of urine to determine the extent of fluoride excretion. If exposure is controlled so well that no workman repeatedly excretes fluoride at 8 ppm, there is little likelihood that ill effects will result from atmospheric exposure to fluoride, except for rare cases of slight increase in radiopacity in bone after many years of occupational exposure. When urinary fluoride does not exceed 4 ppm, none of these effects will be seen. Claims of damage are discussed in the last chapter.

7. McClure, F. J., Editor: FLUORIDE DRINKING WATERS. A Selection of Public Health Service Papers on Dental Fluorosis and Dental Caries; Physiological Effects, Analysis and Chemistry of Fluoride. Bethesda, Md., U. S. Department of Health, Education, and Welfare, Public Health Service, National Institute of Dental Research (Public Health Service Publication No. 825), 1962, 636 pp.

As stated in the subtitle, this book brings together under one cover the reports of investigations by the Public Health Service concerning fluoride-bearing waters. The first article in this volume was published in 1901, and the most recent appeared in a scientific journal in 1962.

The individual articles are grouped under the following headings:

Endemic Dental Fluorosis (Mottled Enamel)
Relation of Dental Caries to Fluoride Drinking Waters
Fluoridation of Drinking Water and Control of Dental Caries:
  Reduction in dental caries by fluoridated drinking water
  Engineering problems in water fluoridation
  Caries inhibition by fluoride not provided by community drinking water
Topically Applied Fluoride and Dental Caries Control
The Physiological Effects of Fluoride — The health status of human populations exposed to fluoride drinking water
Experimental Laboratory Research Relative to Effects of Fluoride:
  Experimental dental fluorosis
  Inhibition of experimental dental caries by fluoride
  Fluoride metabolism and retention in calcified tissues
Quantitative Analysis and Chemical Reactions of Fluoride:
  Analysis of fluoride
  Reactions of fluoride ion with enamel and dentin
  Water defluoridation

The significance of the subject matter as covered by the articles within the separate sections is stated in brief introductions.

Abstracts of a number of the papers are included in this bibliography.

8. American Dental Association: FLUORIDATION ISSUE. Journal of the American Dental Association 65:578-717 (Nov.), 1962.

The editorial introducing the articles states that "the adjustment of the fluoride concentration of a water supply to a level optimal for dental health has proved its worth and is here to stay."

The special issue of the Journal has been prepared to provide civic leaders and other spirited citizens with basic information regarding all aspects of fluoridation, and with facts and figures that refute the unscientific, unsupported arguments of the antifluoridationist. Opponents to man's continuous struggle to improve himself have existed from the beginning of man. Examples of this attitude are given as related to discoveries, technologic advances, and progress in medicine and dentistry.

The individual articles are as follows:

"Effectiveness of Water Fluoridation," by D. B. Ast and B. Fitzgerald; see Abstract No. 100

"Feasibility of Water Fluoridation," by A. P. Black; see Abstract No. 151

"Economy of Water Fluoridation," by J. R. Blayney. Aside from a saving in better dental health, and hence in general health, which cannot be measured in a monetary sense, experience in Evanston has shown that without benefits of fluoridation the cost of dental treatment for the 6- to 8-year range would have been 35 to 40% higher, and for the 12- to 14-year range, at least 50% greater.

"Safety of Water Fluoridation," by F. A. Smith; see Abstract No. 87

"Fluoridation Safe, Maintain International, National and Community Health Authorities."
Excerpts of a limited number of published statements of health organizations and authorities are given: American Dental Association; American Medical Association; World Health Organization; Ministry of Health, Great Britain; Commission of Inquiry on Fluoridation of Public Water Supplies, New Zealand; Committee Appointed by Province of Ontario, Canada; Brantford, Ontario, Canada, Study; Bartlett-Cameron, Texas, Study; Newburgh-Kingston Caries-Fluorine Study; Robert A. Kehoe, M. D., on the question of public safety.

"Dental Fluorosis in Grand Rapids During the Seventeenth Year of Fluoridation," by A. L. Russell; see Abstract No. 103

"Chicago's Experience with Fluoridation," by S. L. Andelman
Chicago began fluoridation in 1956. The cost per capita including suburbanites is about 13.8 cents a year.

"The Aurora-Rockford, Ill., Study I. Effects of Water Having Naturally Occurring Fluoride on Dental Health of Young Adults," by H. R. Englander, R. de Palma, and R. G. Kesel; see Abstract No. 119

"Community Organization and Community Education for Fluoridation in Newton, Massachusetts," by T. F. A. Plaut.
In 1961, Newton approved fluoridation by majority vote. The various aspects of the 23-month campaign are reported.

"How Citizens Can Help the Community Health Team Achieve Fluoridation," by S. J. Buckman.
The work of the fluoridation committee of the Citizens Association of Memphis and Shelby County, Tenn., in circulating petitions and conducting an educational program is described by its chairman. The petition used is shown.

"Fluoridation: Organizing a Community for Support of Water Fluoridation," by F. M. Erlenbach.
On the basis of experience in Connecticut, a well-planned community organization, down to the precinct level, is essential for the success of a fluoridation campaign. The work of subcommittees and approach to people is described.

"Georgia's Water Fluoridation Program," by J. E. Chrietzberg; see Abstract No. 101

"Fluoridation, the Health Department's Challenge: The Tennessee Story," by C. L. Sebelius
The health department, through its divisions, should serve as the coordinating agency to initiate a successful program of fluoridation. Programs should be planned with, rather than for people.

"Legal Aspects of Fluoridating Community Water Supplies," by H. W. Butler; see Abstract No. 122

"Political Aspects of Fluoridation," by D. R. McNeil
As the opposition has insisted on thrusting fluoridation into the political arena, proponents must meet them on this field. Steps to be taken in planning a campaign are outlined.

"Publicity During a Fluoridation Campaign," by E. M. Bishop

"Contributions of the Social Sciences to Fluoridation," by S. S. Kegeles.
The findings of recent behavioral studies on fluoridation are reviewed, and future studies are discussed.

"Fluoridation: Analysis of a Successful Community Effort — Challenge to State and Local Dental Societies," by L. F. Menczer
The story of nine years of effort to achieve fluoridation by the Metropolitan District in Hartford County is described.

"Fluoridation: Analysis of an Unsuccessful Community Effort," by S. Weil, Jr.
The 1960 campaign in Cincinnati, and the reasons for the defeat at the polls are discussed.

"An Appraisal of Objections to Fluoridation," by K. A. Easlick; see Abstract No. 132

"Comments on the Opponents of Fluoridation," by the Bureau of Public Information, American

Dental Association.

The purpose of the article is to furnish information on the background, qualifications and activities of the best known opponents of fluoridation, by presenting excerpts of material published in various sources.

"The Petitionee Who 'Opposes' Fluoridation," by L. F. Menczer.

Investigation of a petition that fluoridation by the Metropolitan District in Hartford County be discontinued, revealed that many of the petitionees had signed without real knowledge of the issues, or husbands had signed for wives; others had done so at the petitioner's insistence.

Statements favoring fluoridation by the following leading physicians and citizens are also included: Dr. Benjamin Spock, pediatrician; Richard J. Daley, Mayor of Chicago; Clare Boothe Luce, writer and diplomat; Bud Wilkinson, consultant to the President on youth fitness; Dr. Albert B. Sabin; Robert F. Kennedy, Attorney General; Dr. Paul Dudley White; Dwight D. Eisenhower; George Meany, President of AFL-CIO.

The Issue closes with an editorial, "Dentistry; Foremost Champion of Fluoridation," pointing out that fluoridation, as have most previous public measures, is undergoing 3 stages of experience: a period of acclaim and urgent action; a period of wavering and emotional reaction; and a period of orderly, productive growth terminating in a safety measure essential to man's modern way of life. In a resolution submitted by the Council on Dental Health at the 103rd session of the Association, the efforts of the individual dentist and the dental society toward acceptance of water fluoridation are acknowledged. "The tactics of those who oppose fluoridation, however, are of such nature as to warrant, and command, professional leadership beyond the usual point. . . . The individual dentist and the dental society now have not only the obligation to support but also to initiate, when necessary, programs of acceptance of the fluoridation of the community water supply," enlisting whenever possible, the aid from other professions and individuals and agencies interested in the public health.

2. OCCURRENCE OF FLUORIDE IN NATURE

Fluorine, ranking seventeenth in abundance among almost one hundred known elements, is widely distributed in nature. Its occurrence in living tissue, which properly includes plants and all lower organisms, represents its uptake from some source, and its absorption, utilization, storage and elimination by living organisms.

A distinction is made in this bibliography between the occurrence of fluoride in the environment of man, and the occurrence in the tissues of warm-blooded animals and man. The environment of man constitutes the sources of intake of substances from air, water and soil, and from minerals that may be inhaled directly as dusts or eaten after their deposition or incorporation in vegetables or other food products. Publications concerning these — the natural sources of fluoride intake — are included in this section. Included also is the estimated intake by human beings, where this has been the principal subject of the investigation. Investigations of the concentrations of fluoride occurring in living warm-blooded animals and in man, on the other hand, are listed in Sections 3 and 4.

In addition to the high fluoride content of some waters as reported in the literature, the concentrations in soils and dusts as they occur in some regions are of particular interest. These must be taken into account in considering the possible intake by man in these regions, if foods are not protected against dusts or if proper hygienic procedures are not observed.

The literature reporting the presence of fluoride in the environment is voluminous. Only a few of the significant articles and recent reviews are listed here.

9. McClure, F. J. (National Institute of Health, Bethesda, Md.): INGESTION OF FLUORIDE AND DENTAL CARIES. QUANTITATIVE RELATIONS BASED ON FOOD AND WATER REQUIREMENTS OF CHILDREN ONE TO TWELVE YEARS OLD. American Journal of Diseases of Children 66:362-9 (Oct.), 1943.

The results of studies on the relation of fluoride concentration in public water supplies and dental caries are reviewed. The daily fluoride intake of children, 1 to 12 years old, from drinking water containing 1 ppm fluoride and from food containing 0.1 to 1 ppm fluoride in dry substance is estimated as shown below. On the basis of its preventive effects on dental caries, it is suggested that thought be given to the use of supplemental fluoride in children's diets in areas where the water supplies contain suboptimal amounts of fluoride.

Calculations of the quantity of supplemental fluoride required must take into account the fluoride present naturally in the local water supply.

Age years	Body wt. kilogram	Daily fluoride intake: fluoride in water, 1 ppm; in food, 0. 1 to 1 ppm			
		From drinking water milligram	From food (dry substance) milligram	Total daily from food and drinking water, mg.	Total daily mg. /kg. body wt.
1-3	8-16	0. 390-0. 560	0. 027-0. 265	0. 417-0. 825	0. 026-0. 103
4-6	13-24	0. 520-0. 745	0. 036-0. 360	0. 556-1. 105	0. 023-0. 085
7-9	16-35	0. 650-0. 930	0. 045-0. 450	0. 695-1. 380	0. 020-0. 068
10-12	25-54	0. 810-1. 165	0. 056-0. 560	0. 866-1. 725	0. 016-0. 069

10. Robinson, W. O., and Edgington, G. (U. S. Department of Agriculture): FLUORINE IN SOILS. Soil Science 61:341-53 (May), 1946.

In reviewing the occurrence of fluoride in soil, the work of Clarke and Washington (1924) is cited, according to whom fluoride averages 290 ppm in the 10-mile crust of igneous and sedimentary rocks and is an essential element of numerous minerals. Many soft coals also contain as much as 100 ppm. Volcanic gases contain considerable fluoride, and some soils have undoubtedly been enriched by this source. Soils may become enriched also by fertilizers and locally by emissions from certain industrial operations, although in the case of the latter, every effort is made to recover them. The contribution of insecticides to soil fluoride is of little consequence, being small and local.

The authors had analyzed the fluoride content of 30 profiles, 137 samples in all, of representative soils of varied texture; the parent material and geographic distribution are given. This fluoride content varies from a trace to 7, 070 ppm in an unusual Tennessee soil containing phosphate rock. The average in surface soils is 292 ppm. In general, the fluoride content increases with the depth of the soil. Fluoride is considerably concentrated in the colloidal matter.

Much of the fluoride in soils highest in fluoride is in the form of apatite. Evidence, however, is presented to show that, in general, the main source of fluoride in the ordinary soil is the micaceous clays. In general, there is no correlation between the phosphorus and fluoride content of soil where the fluoride present is not mainly in the form of apatite. It is shown that 6 samples of micaceous clays, which probably occur in soil, have fluoride contents ranging from 300 to 7, 400 ppm averaging 3, 730 ppm, with one Ordovician bentonite containing the maximum quantity.

Much of the fluoride added to the soil in the form of superphosphate is retained by the heavier textured soils. Coarse, sandy soils retain less of the added fluoride. Added fluoride in the form of superphosphate does not appear to increase significantly the fluoride content of plants. The fluoride content of 28 samples of vegetation grown on a soil of known fluoride content (137 ppm at the surface, and 172 ppm at subsurface) is listed. This soil had been liberally supplied with superphosphate for about 15 years. There was no known source of atmospheric contamination. Seeds and fruit had lower fluoride than leafy and root parts. Few items exceeded 10 ppm (dry-weight basis), and most ranged to 5 ppm. Poke and spinach were highest in fluoride content, 42. 3 and 28. 3 ppm, respectively.

11. McClure, F. J. (National Institute of Dental Research): FLUORINE IN FOODS. SURVEY OF RECENT DATA. Public Health Reports (U. S.) 64:1061-74 (Aug. 26), 1949.

Information as to the fluoride content of various foods and beverages, as reported in the literature has been assembled for the purpose of comparison and for the evaluation of the amount of fluoride ingested in the average human diet. Since the Willard and Winter or a modification of it has become the most generally used method, the data are comparable with few exceptions. In some instances, information was lacking as to the "dry" or "fresh" basis of analysis, and wherever desirable to supply it, the reviewer's judgment was based on the analytical figure.

The various types of foods constituting a normal diet, as listed under different groupings, contain fluoride in the following concentrations on fresh basis:

	ppm
Meats	average 0. 2 to 0. 3
Fish (fresh and canned)	from 0. 1 to 26. 9
Hen's eggs	average 0. 2 to 0. 4
Cow's milk	0. 1 to 0. 2
Tea	from 3. 2 to 398. 8
(1 cup of tea contains about 0. 12 mg.)	
Citrus fruits	average 0. 1 or less
Noncitrus fruits	most values from 0. 09 to 0. 9
Cereals and cereal products	most values from 0. 1 or less, to 0. 3

The fluoride content of plants grown in soil containing added fluoride, or when watered with fluoride-containing water, or grown in regions of low- or high-fluoride waters (Arizona) is also listed. In summary, the majority of foods found in the average diet contain from 0. 2 to 0. 3 ppm or less fluoride in the food as consumed. Tea and seafoods are notable exceptions. Cow's milk contains very little fluoride and is not influenced by a cow's ration or drinking water. Fluoride in soil and water has little or no influence on the fluoride content of edible plant produce. Although the data are limited, it appears that natural food-borne fluoride is largely available for body assimilation. Exclusive of drinking water, the average diet provides 0. 2 to 0. 3 milligram of fluoride daily.

[EDITORIAL COMMENT: Several investigations have shown that a high fluoride content of soil or of water does not increase the fluoride content of plants (see Abstract No. 10). W. Machle, E. W. Scott, and J. Treon ("Normal Urinary Fluorine Excretion and the Fluorine Content of Food and Water," American Journal of Hygiene 29:139-45, 1939) had analyzed a large number of foods grown in areas with fluoride-deficient waters, 0 to 0. 8 ppm, and in those with higher waterborne fluoride, from 1 ppm to 18 ppm. No correlation could be found, some vegetables grown in the high-fluoride areas showing even a lower fluoride content than in the fluoride-deficient regions.]

12. Williamson, M.M. (Royal Geographical Society): ENDEMIC DENTAL FLUOROSIS IN KENYA: A PRELIMINARY REPORT. East African Medical Journal 30:217-33 (June), 1953.

[COMMENT: Very high concentrations of fluoride are found naturally in numerous areas. This publication, reporting detailed findings under different conditions prevailing in a region of Africa, clearly exemplifies this.]

Since World War II, the rapidly expanding population and industry have created problems of water supply, and many boreholes have been sunk to supplement the supply. Signs of dental fluorosis are beginning to show in Europeans who had earlier obtained their domestic water supply from rain water and rivers. The source of domestic water supplies for the African population is in the main obtained from springs and rivers. Many of these dry up during the hot season, and the supply is then obtained from shallow to deep wells sunk in dry river beds. A total of 850 analyses were made of such waters from various sources (by the Government Chemist of Kenya): 339 of them contained fluoride at 0.1 to 0.9 ppm; 146, at 1 to 1.9; 148, at 2 to 3. 9; 77, at 4 to 5. 9; 72, at 6 to 9. 9; 49, at 10 to 19. 9; 6, at 20 to 29. 9; 12, at 30 ppm and over.

Fluoride content of some surface waters and dusts is also tabulated; that of lakes ranged from 0. 55 to 2, 800 ppm; of rivers and springs, from 0. 45 to 49 ppm. The highest fluoride content of wells was 39 ppm; that of dams, 10.7; of boreholes, 43.5. The fluoride in dust ranged from 13 to 5, 600 ppm; that collected from shelves in a house in Nakuru contained 150 ppm. Many of the waters have high pH values: from 8 to 10 pH.

The geological structure of Kenya is such that one would expect high fluoride levels. Large areas of the country are covered by formations due to comparatively recent volcanic action. The surface waters percolate through the soil, in many areas consisting of high percentage of volcanic ash, and then pass through the weathered trachyte tuffs or lavas to form a water table over the more compact and impervious phonolite or structures of the basement system.

Over 4, 500 children and adults were examined in different parts of Kenya for signs of the varying degrees of mottled enamel. Several cases were seen where the deciduous dentition was affected. The incidence of mottled enamel in the 3 racial groups so far surveyed showed the following prevalence: Europeans (922 individuals, age 7-13), 23%, with 3. 2% moderate and severe; Asian (626 individuals, age 7-16), 57. 9%, 11. 8% moderate and severe; African (3, 014 individuals, age 7-18, and over) 37. 9%, 9. 2% moderate and severe.

13. Williams, D. B. (Public Utilities Filtration Plant, Brantford, Ont.): THE FLUORIDATION OF DRINKING WATER. Journal of the Canadian Dental Association 21:665-77 (Dec.), 1955.

SUMMARY: Whether fluoride occurs in water naturally or is added mechanically, it is the same fluoride ion that is found in water. Pure water is never found in nature or as delivered by waterworks. Waterworks can only give hygienically pure water.

In his discussion of the operational aspects of fluoridation, the author begins with an account of the history of the use of chemicals in waterworks practices. While the use of powdered activated charcoal to remove taste and odors from water started some 25 years ago, crude charcoal was used for the same purpose 3,000 years ago in Egypt. Chlorination, as well as dechlorination are about 50 years old. Settling and filtration were done in antiquity and even chemical coagulation by means of aluminum sulfate is said to have been done in China some 6,000 years ago.

The addition of fluoride in waterworks practice was begun in 1945. However, natural fluoridation has been going on in varying degrees in various parts of the world ever since the congealed rocks were sufficiently cooled to permit the condensed vapors of the atmosphere to run over or through them. The same process goes on now, so that in all waters fluoride may exist from very minute to high concentrations, such as in the United States, at 35 ppm in Climax, Colorado.

Considerable argument has arisen over natural versus artificial fluoridation. Actually, no one knows in what form fluoride which usually occurs in very small amounts, or any of the other minerals which run generally to some 400 to 800 ppm, exist in water. The analysts cannot tell how the metals and radicals, or ions, are bound together; at best they can give an empirical formula. However, "this entire dilemma is swept away when it is realized that even in a highly mineralized water such as 400 to 800 ppm the dilution is so great that we do not have complete molecules existing but rather the metals and radicals exist in ionic form. Thus rather than calcium bicarbonate we will have free calcium ions and free bicarbonate ions and so it is for all the other metals and radicals including the fluoride ion. Therefore at the degree of dilution found in natural or artificial fluoridation the fluoride ion is free and it does not matter if it originally came from a calcium fluoride complex in some rock or if it has been added as sodium fluoride or sodium silicofluoride at a waterworks."

The chemicals used in fluoridation, the calculation of dosage, and the actual application of the chemicals in the waterworks are discussed and various questions that have been raised are answered. One of the fears expressed pertains to accidental or intentional release of lethal amounts of fluoride into the water supply. This fear is allayed by the fact that it would require more than 4 tons per million Imperial gallons of water to make people sick, but not kill them, and at a pumpage of 7 million gallons per day, in excess of 28 tons per day for several days would be required. As the stock on hand at Brantford is less than 28 tons, intentional poisoning of the population would be impossible.

In regard to the concern about the "purity" of water raised by some people, the author points out that pure water is never found in nature, nor as delivered by waterworks. All waters, even the well waters, considered to be very pure, contain hundreds of ppm of other chemicals which are not removed in the treatment of water. Alongside the hundreds of other chemical constituents in the delivered water, totaling 400 ppm and more, the amount of fluoride at 1 ppm is insignificant, as it represents 0.0001% of the entire water.

No water authority can attempt to give "chemically pure" water, but everything possible is done to deliver "hygienically pure" water.

[ABSTRACTOR'S NOTE: Nichols (see Abstract No. 4) also presents a clear explanation of the nature of fluoride occurring in water. He points out that natural fluoride occurs from the dissolution, or ionization of fluorides present in minerals upon contact with water. Whether this occurs naturally or from added compounds, the fluoride ions yielded are identical.]

14. Cholak, J. (University of Cincinnati, O.): FLUORIDES: A CRITICAL REVIEW. I. THE OCCURRENCE OF FLUORIDE IN AIR, FOOD, AND WATER. Journal of Occupational Medicine 1:501-11 (Sept.), 1959.

Fluoride, in combined form, is one of the most widely distributed elements in the earth's crust.

Recent advances and improvements in analytical techniques have led to the verification of its presence in many natural materials. Today it is doubtful, when the size of the sample is adequate, that air, water, vegetation, or food products absolutely free from fluoride can be found.

Data on the occurrence of fluoride in air, food, and water are compiled from the literature as well as from direct observations. Recent analyses with improved methods, and aspiration of large volumes of air through liquid collecting media, showed average concentrations from 0.02 to 2.00 parts of fluoride per billion parts of air in a number of residential and rural areas in the U. S. In considering atmospheric pollution by fluoride, it is pointed out that in determining the reliability of reported data, the volume of air sampled, the location of the sampling site in relation to the source of pollution, the method of sampling, the sensitivity of the analytical method, and the nature of the pollution, gaseous or particulate, must be taken into account.

Fluoride concentrations in vegetation vary in different parts of the plant and depend upon the solubility of the fluoride mineral present in the soil and the occurrence of fluoride in the atmosphere. Generally, plants contain from 0.1 to 10.0 ppm fluoride, except for tea plants which normally contain 8 to 400 ppm and, in some cases, show values as high as 1,900 ppm. Comparison of daily food rations in various countries showed a low of 0.18 to 0.3 milligram fluoride in Canada, and the highest values of 2.33 to 3.13 milligrams in Bartlett, Texas. High fluoride concentrations were found also in seafoods and wines. With these exceptions, the average fluoride content in food items was 0.1 to 0.3 ppm. A list of fluoride concentrations in drinking and mineral waters as determined in many countries is given. Concentrations in drinking water are reported to be as high as 53 ppm (South Africa).

15. U. S. Public Health Service, Division of Dental Public Health: NATURAL FLUORIDE

CONTENT OF COMMUNAL WATER SUPPLIES IN THE UNITED STATES. U. S. Public Health Service Publication No. 655, 1959, 111 pp.

A census of communities having at least one water source containing fluoride naturally at concentrations of 0.7 ppm or more was made in 1956-1957 by the Dental Directors of all state health agencies at the request of the U. S. Public Health Service. Whenever a community had more than one water source, all sources of that place were shown, including those with fluoride levels of less than 0.7 ppm, resulting in averages of less than 0.7 ppm for the communities.

The distribution of naturally fluoridated water supplies is shown in a map of the United States and in graphs by states and regions, by average concentrations and by size of communities. Tables show populations for single and multiple water sources and for communities with maximum and minimum fluoride content, and by fluoride concentration of water sources, by states; by water sources with specific fluoride content; by population size of community. Communities are also listed individually, by states, with population and minimum and maximum fluoride content, and by grouping under certain ranges of fluoride content.

Among the 1,903 communities enumerated (1,119 with single, 320 with multiple sources, and 464 not specified as to number of sources), natural fluoride concentrations were found to be as follows: average of 0.7 to 1.1 ppm in 895 communities with about 4,256,000 residents; 1.2 to 1.4 ppm in 263 communities with 598,000; 1.5 ppm and more, in 620 communities with 1,400,000 people; and averages of less than 0.7 ppm in 125 communities (having more than one water source, some containing less than 0.7 ppm) with 698,000 persons. Maine, Vermont, Massachusetts, Pennsylvania, and Delaware reported no known communal sources with natural fluoride levels of 0.7 ppm or more.

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 3, 4, 5, 6, 7, 16, 19, 21, 43, 46, 81, 84, 85, 88, 89, 94, 142.

3. METABOLISM OF FLUORIDE IN ANIMALS

The presence of fluoride in animal tissues was discovered in 1802. However, ninety years passed before the publication of the first investigation of its metabolic fate in a dog fed large doses of sodium fluoride. Brandl and Tappeiner were the first to report in 1892 the deposition of fluoride in skeletal tissue after prolonged ingestion of sodium fluoride. From the middle of the past century until the later twenties of this century, animal experimentation was concerned mainly with the acute effects of fluoride. Since the early 1930's, the absorption, elimination and retention of fluoride with prolonged intake have been studied extensively, and well over a thousand publications reporting observations on animals in the laboratory and in the field have appeared.

Aside from giving insight into the metabolic fate of a substance, results obtained in animal experimentation can serve only as a guide as to what organs or functions may be affected when excessive quantities of the substance have reached the body. The doses of fluoride employed in animal experimentation and the amounts ingested by livestock in forage and feed concentrates are generally far higher than those absorbed by man from water containing fluoride in concentrations even greater than 1 ppm. For example, as seen particularly in Abstracts No. 19, 22, 23, and 24, animals tolerate considerable quantities of fluoride in food and drinking water. Also, concentrations of 9 to 15 ppm were required to produce the first changes in the teeth of rats, visible in enlarged photographs.

The publications selected for inclusion in this Section are a few of the significant contributions to the knowledge of the metabolism of fluoride.

16. Velu, H. (Department of Animal Production, Morocco): Le darmous (ou dermes); fluorose spontanée des zones phosphatées. (DARMOUS (OR DERMES); SPONTANEOUS FLUOROSIS OF PHOSPHATE ZONES.) Archives de l'Institut Pasteur d'Algérie 10:41-118, 1932.

The occurrence and the signs of the dental dystrophy found in North Africa (Algeria, Tunisia, Morocco) in human beings and in animals that had lived in the phosphate zones from birth, or until the eruption of permanent teeth, are described. In addition to the changes found in teeth, deformation of the lower maxillary with exostoses was seen in cattle and in sheep, more rarely in horses. This condition had been studied since 1923, but the exact cause had not been established until 1931.

Experiments extending over 2 years with various animals demonstrated that this is a state of poisoning by fluoride (contained in all phosphates), induced by the long ingestion of water coursing through the phosphate deposits. Effects obtained on animals included inhibition of growth, muscular atrophy, suppression of estral cycle, decreased appetite, and fatal cachexia. The animals had been fed calcium fluoride, water standing over a bed of phosphates, and the natural phosphates. The fluoride content of the North African phosphates ranged from 3.35 to 4.28% (33,500 to 42,800 ppm) as determined in 13 samples.

[EDITORIAL COMMENT: Velu, Doctor of Veterinary Medicine, related the occurrence of mottled enamel in livestock to the ingestion of excessive amounts of fluoride at the same time as, but independently of, McKay (Abstract No. 88) and Smith (Abstract No. 89) in the United States. The investigations on humans living in the phosphate zones of Morocco were done by M. Gaud (Director of Public Health), A. Charnot and M. Langlois ("Le darmous humain (Human Darmous)," Bulletin de l'Institut d'Hygiéne du Maroc, Nos. 1 and 2, 1934, and Revue de Stomatologie 37:732-41, 1935), who found that except for severe dental fluorosis, in spite of careful examination, no disturbances of general health, such as reported by Velu as a result of his observations on animals, have been demonstrated in human beings. They also included in their studies experiments with animals and extensive analyses of the soil, suspended mud, and vegetation. They calculated that the daily fluoride intake of a 25-kilogram sheep totals 156.15 milligrams: water contributing 1.25, mud 7.5, vegetation 33.8, and dust 113.6 milligrams. This led them to the conclusion that it is not the waters of the region, but the vegetation contaminated with dusts which causes the severe changes in the animals, particularly the ruminants.]

17. Phillips, P. H., Hart, E. B., and Bohstedt, G. (University of Wisconsin, Madison): THE INFLUENCE OF FLUORINE INGESTION UPON THE NUTRITIONAL QUALITIES OF MILK. Journal of Biological Chemistry 105:123-34 (Apr.), 1934.

SUMMARY: The fluoride content of cow's milk averages 0.05 to 0.25 ppm. Relatively large quantities of fluoride ingested by the cow in the diet or drinking water will cause only a very slight increase in the quantity of fluoride in her milk.

Over a 140-day period, rats fed mineralized milk from cows receiving 0.022%, 0.044%, and 0.088% (220, 440, 880 ppm) fluoride (as rock phosphate) in grain mixture did not differ in growth, food consumption, or residual fluoride in body ash from rats fed mineralized milk from a cow on the basal ration alone. The fluoride content of normal milk was 0.05 to 0.25 ppm, average 0.138, while that of milk from cows receiving rock phosphate supplements was only slightly higher or the same, 0.126 to 0.192 ppm. Lactation was without effect on the fluoride content of the milk.

Addition of 0.5, 1.0, and 2.0 milligrams (mg.) of fluoride per liter to normal milk (0.5, 1.0, 2.0 ppm) produced no evidence of fluoride toxicosis. The characteristic bleaching effect upon the incisor teeth was entirely absent. However, residual fluoride in body ash increased from 0.475 to 0.83 mg. per 100 grams (g.) of body weight (4.75 to 8.3 ppm) in controls to 5.11 to 10.33 mg. per 100 g. of body weight (51.1 to 103.3 ppm) in rats receiving milk containing 2.0 mg. added fluoride per liter.

It is concluded that the fluoride content of milk is comparatively difficult to influence by dietary means.

18. Lee, C. F., and Nilson, H. W.: STUDY OF THE METABOLISM OF NATURALLY OCCURRING FLUORINE IN CANNED SALMON AND MACKEREL. U. S. Bureau of Fisheries, Investigational Report No. 44, 1939, 15 pp.

SUMMARY: The concentrations of fluoride stored in the body of rats ingesting fluoride naturally contained in fish were 3 times lower than of rats fed inorganic fluorides.

Four groups of 11 weanling rats each were fed fresh canned pink salmon (5.77 ppm fluoride), dried canned salmon (19.34 ppm), fresh canned mackerel (26.89 ppm), and canned dried mackerel (84.47 ppm), respectively. A negative control group received basal ration containing 1.28 ppm fluoride and 2 groups of 9 rats each received basal ration + 1.4 ppm inorganic fluoride as sodium fluoride (mean, 2.74 ppm fluoride) and as calcium fluoride (mean, 2.63 ppm fluoride), respectively. Distilled water was used as their drinking water.

The 4 groups of rats fed the fish diets maintained excellent health and an average growth rate of 9 grams per week over the 12-week period. Analysis of the entire carcasses at the end of this time showed that 67% of the fluoride from the basal diet + inorganic fluoride, but only 21% of that from fish was stored in the body. With 20.1 ppm fluoride present in the salmon diets, none of the teeth showed any striations (although at the higher, 84.47-ppm diet, these changes were seen), while 7 ppm inorganic fluoride has been known to produce this effect.

[EDITORIAL COMMENT: This study is included because high fluoride levels are reported to occur in fish, where it is present probably mainly in bone. Fluoride contained in animal tissues is not metabolized differently from inorganic fluorides added to the food. However, because fluoride in animal tissues is intimately associated with the presence of insoluble ions, such as calcium and phosphate, the formation of insoluble fluoride aggregates is promoted in the digestive tract. This results in increased fecal excretion, and therefore, lesser fluoride retention in bone. Among other reports of this finding is that of J. M. Taylor, et al. (Toxicology and Applied Pharmacology 3:278-89, 1961) who saw only 10 to 15% of the fluoride present in the stock Purina Fox Chow Meal (25 to 30 ppm) to be retained in rats; lower retention was also found by E. J. Largent (Abstract No. 66) when bone meal was ingested by human subjects.]

19. McClure, F. J.: FLUORIDES IN FOOD AND DRINKING WATER. A COMPARISON OF EFFECTS OF WATER-INGESTED VERSUS FOOD-INGESTED SODIUM FLUORIDE. National Institute of Health Bulletin No. 172, 1939, 53 pp.

SUMMARY: No noticeable differences were observed in rats, which could be attributed to whether sodium fluoride was ingested in food or in water.

The effects of the prolonged ingestion by growing young rats of sodium fluoride added to food were compared with those when sodium fluoride was added to the drinking water. The quantities of sodium fluoride added to food or water were equivalent to 22.6, 45.2, and 90.4 ppm in water. Nine rats were used at each level of intake over a period of 7 weeks. The diet (without added fluoride) contained an average of 4 ppm.

As shown by the average daily body gain, ash and fluoride content of bones and teeth, the appearance of the teeth, and the total fluoride retained in the final body weight, there were no noticeable differences which could be attributed to either of the two media of fluoride ingestion.

In another series of experiments, groups of rats were fed food containing fluoride at 600 ppm or water with 80 to 316.6 ppm fluoride. Acute effects of sodium fluoride ingested in the drinking water at about 180 ppm of fluoride were observed, confirming previous observations. These acute effects of water-ingested fluoride at certain high levels of intake are not to be confused with conditions and effects accompanying fluoride consumption in drinking waters of mottled enamel areas.

Judging from fluoride balance studies on growing young rats, the average total retention of fluoride from sodium fluoride may equal 30 to 40% of the intake at the concentrations studied. By far the greater portion is deposited in the bones and teeth. The degree of dental hypoplasia in the rat is directly correlated with the quantity of fluoride present. A chalky white appearance of tooth pigment was evident at 9- to 15-ppm intake in enlarged photographs, but not to the naked eye. It has been suggested that the fluoride content of the bones and teeth of experimental animals may serve as a biologic test for effective fluoride in food, and as a means of indicating a pathologic condition in the affected tissue. Observations on the effects of sodium fluoride as fed to young rats include the following: (a) there is the suggestion of a stimulating effect of 22.6 ppm of fluoride in the diet on appetite and perhaps on the daily body gain; (b) a stimulating effect of fluoride on water-drinking was observed; (c) sodium fluoride at a level equivalent to 45 ppm or more of fluoride in food and water gave evidence of a reduced rate of gain; (d) an increase in ash content of bones occurred from sodium fluoride ingested at levels of 22.6 to 600 ppm of fluoride. In the case of the rat, 0.03 to 0.04% fluoride (300 to 400 ppm) represents approximately the maximum that may be present in the whole tooth with no change in normal macroscopic appearance of enamel. The fluoride content of a large number of foods, as reported in the literature, is summarized.

20. Borei, H. (University of Stockholm, Sweden): INHIBITION OF CELLULAR OXIDATION BY FLUORIDE. Arkiv för Kemi, Mineralogi och Geologi 20A, No. 8:1-215, 1945.

A complete review (as of the date of publication) is presented of the effects of fluoride on enzymic processes. Working with yeasts, bacteria, plant tissue and various animal and human tissues investigators since the 1890's have found by in-vitro studies that at low concentrations fluoride activates certain biochemical systems, but at higher concentrations may inhibit them. Certain cells, for example yeasts, develop a habituation to large concentrations of fluoride. Fluoride inhibition of these processes depends, in addition to concentration, upon many other factors, such as treatment of the substrate, its pH, the presence of metals in the system, and the presence or lack of oxygen (aerobic vs. anaerobic conditions).

The fluoride-sensitive link in the respiratory chain lies in the cytochrome system. Certain components of some enzyme systems, on the other hand, are not affected by fluoride.

All known fluoride complexes with iron in hemoproteins are reviewed. The investigations prove that no such compounds involving iron in the cytochrome system are known to exist within the physiological pH range.

The toxicity of fluoride for intact mammals is mentioned only briefly in connection with acute poisoning by inorganic compounds, where fluoride has been considered to act principally by precipitating calcium ions from the blood and tissues, and in connection with severe cases of industrial and endemic skeletal fluorosis.

> [EDITORIAL COMMENT: Fluoride, in relatively high concentrations, has been useful in the in-vitro study of enzyme systems for the purpose of characterizing their properties and establishing their presence in various tissues.
>
> From the more practical and applicable point of view, recent in-vitro studies of the effect of low concentrations of fluoride on the activity of salivary and human prostate acid phosphatase and yeast enolase (enzymes said to be sensitive to fluoride) have indicated that concentrations of fluoride ion that could be derived from water fluoridation did not alter enzymatic activity (Smith, Q. T., Armstrong, W. D., and Singer, L.: "Inhibition of Human Salivary and Prostatic Acid Phosphatase and Yeast Enolase by Low Fluoride Concentrations," Proceedings of Experimental Biology and Medicine 102:170-3, 1959). Fluoride in concentrations many times that expected in the body from a normal fluoride intake did not affect the activity of salivary amylase (McClure, F. J.: "Effect of Fluoride on Salivary Amylase," Public Health Reports (U.S.) 54:2165-71, 1939).
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> Only a limited number of studies have been concerned with enzymatic changes in various tissues of animals that had received fluorides, generally at high dosage in acute experiments. In one preliminary study (Frajola, W. J.: "Fluoride and Enzyme Inhibition," Abstract No. 5), acid and alkaline phosphatase, lactic dehydrogenase, the glutamic-oxalacetic and pyruvic transaminase activities were determined before and after daily ingestion of 16 milligrams of fluoride by human subjects. No correlation with the fluoride ingested was obtained in repeated tests. Clinically, the determination of enzyme activity is used extensively today to detect functional changes or the presence of certain organic diseases. For example, serum alkaline phosphatase activity is useful in detecting liver dysfunction. This test has been applied in high-fluoride areas, and the results were found to be the same as in low-fluoride areas (see Abstract No. 35).]

21. Mitchell, H. H., and Edman, M. (University of Illinois, Urbana): FLUORINE IN SOILS, PLANTS, AND ANIMALS. Soil Science 60:81-90 (July), 1945.

In reviewing the distribution of fluorine in nature, its association with soil phosphates is considered to be particularly significant in plant and animal nutrition. Fluorine contributes to the insolubility of phosphates and seems to be essential to their preservation in the soil through the ages. Volcanic activity contributed a considerable amount of fluoride at about the same time as the deposition of the primary phosphates occurred in the United States. The ratio of phosphorus to fluorine in the earth's crust is roughly 4 to 1. Rain water contributes to soil about 0.15 lb. of fluoride per acre yearly (as found in Tennessee where much coal, which may contain as much as 295 ppm fluoride, is burned).

In soil, the relatively insoluble calcium fluoride is the expected combination. There are conditions, such as high pH, that facilitate the reaction of tricalcium phosphate with calcium fluoride to form fluorapatite.

Fluoride is widely distributed in the drinking waters of the United States and throughout the world, few waters being found that do not contain at least 0.05 ppm. The higher concentrations occur in deep well waters, where they originate from deep-seated rock formations. Strangely, in phosphate zones, the waters contain inappreciable concentrations of fluoride (ranges up to 0.7 ppm).

In reviewing the role of fluoride in plant nutrition and its occurrence in plant foods, the fluoride content of the plant, with the exception of the roots, is not readily affected by the concentrations present in the soil. Excepting a few accumulator plants such as tea, few plants contain more than 2 ppm, unless they are contaminated by dusts and fluoride insecticides. The degree of such contamination in interstate commerce is limited by established tolerances. In summary, the plant, aside from external contamination, cannot be held responsible for harmful effects on man and animals.

The dispensability and metabolism of fluoride in the animal body are reviewed in greater detail. Aside from the beneficial effect on teeth seen at relatively low levels of 1 to 2 ppm in epidemiologic and experimental studies, no essentiality for the animal organism had been substantiated until the date of the review.

The metabolism of fluoride in the body is clearly presented on the basis of experimental data on animals, available to that time: (1) of a dietary fluoride contained up to 13 ppm in air-dried food, 30 to 60% of the amount ingested is retained in the body, all but 5% of this in skeletal tissue and the remainder in teeth and soft tissue; (2) about 20% more fluoride is retained when ingested in water; (3) at these low levels of intake aqueous solubility does not determine the extent of fluoride absorption; (4) intermittent feeding induces a less complete retention in the body than does continuous feeding; (5) the growing animal adapts itself to a constant intake of fluoride by excreting larger and larger proportions and retaining less and less; (6) the concentration in the bones responds more to increased intake than does that of teeth; (7) the fluoride content of soft tissue is also correlated with that of the diet. Fluoride is excreted through the kidneys and intestinal tract, in the sweat; the salivary glands secrete it from the blood; the oviduct of the hen transfers it to the egg, and the placenta is permeable to it; the mammary gland is not permeable to fluoride consumed in food or water, even at high levels.

Although the teeth do not acquire as high concentrations of fluoride as do bones, the first signs of excessive intake appear in the teeth. The beneficial effect on caries by waters containing fluoride at 1 to 2 ppm is briefly reviewed. This is the only known preventive treatment against caries; whether the effect is brought about by change in tooth structure, bacteriostatic effect or by change in oral environment, is not known.

[EDITORIAL COMMENT: More recent studies have demonstrated that fluoride in soft tissues is relatively independent of intake and that the mammary gland is permeable to fluoride.]

22. Rand, W. E., and Schmidt, H. J. (Stanford University, Calif.): THE EFFECT UPON CATTLE OF ARIZONA WATERS OF HIGH FLUORIDE CONTENT. American Journal of Veterinary Research 13:50-61 (Jan.),1952.

SUMMARY: Cattle tolerate levels of soluble fluoride in the daily diet as high as 1 milligram per kilogram of body weight (about 450 milligrams for a 1000-pound cow) with no detectable effect except possibly slight mottling and slight wear of the incisor teeth.

The Milky Way Hereford Ranch maintains a Hereford breeding operation on the Home Farm, where the fluoride content of the water supply is 16 ppm, of mixed forage 15 to 25 ppm, and of hay 6 ppm (thus the animal will ingest daily approximately 1.7 milligrams (mg.) fluoride per kilogram of body weight based on the calculation that a 1000-pound animal will consume 21 lb. of feed and 10 gallons of water per day), and on Scottsdale Farm where water has 1 ppm fluoride, forage 11 ppm, hay 1 ppm (the animal will ingest 0.3 mg. fluoride per kilogram of body weight per day). Animals that spent at least half their time on the Home Ranch over a 5-year period showed only slight mottling and wearing of the incisor teeth. It is calculated that they had averaged a fluoride intake of 1 mg. fluoride per kilogram of body weight per day. Their urinary fluoride averaged 16.5 ppm; the somewhat high value is attributed to the fact that samples were taken when the animals were on the "high fluoride" farm. A cow that had been on the "high fluoride" farm continuously for 2 years was slaughtered. Metacarpus showed 2,600 ppm fluoride. All tissues were normal.

At another farm, where the fluoride content of water was 4.8 to 5.1 ppm, of forage 15 ppm, of hay 6 ppm, and of corn silage 3 ppm, cattle were ingesting approximately 0.95 mg. of fluoride per kilogram of body weight per day as long as 10 years (calculated that a dairy cow eats 35 lb. of feed and drinks 15 gallons of water); the only abnormality was occasional slight staining of the incisors. Urine analysis showed average 9.3 ppm fluoride.

At a fourth ranch, water supply containing 18 ppm fluoride was changed in 1945 to one of low fluoride (below 1 ppm). Before that time, cattle showed typical signs of fluorosis. Analysis of metacarpus of cow that had been on ranch from 1940 (slaughtered in 1950) showed 3,360 ppm fluoride on dry, fat-free basis. The urine just prior to slaughter contained 1.7 ppm, showing that the system had ceased flushing off excess fluoride from the skeleton. Although the bone fluoride was still high, it had been undoubtedly much higher at the time the animals were still absorbing abnormal amounts of fluoride before 1945.

These observations confirm conclusions derived from the literature that cattle can tolerate levels of soluble fluoride in the diet as high as 1 mg. per kilogram of body weight per day (roughly 450 mg. for a 1000-lb. cow) over periods as long as from 5 to 10 years, with no detectable effect except possible slight mottling and slight wear of the incisor teeth; a level of 2 mg. per kilogram of body weight per day may result in mottling and severe wear of incisor teeth that form during the period of ingestion, as well as lameness and stiffness, emaciation, and general unthriftiness; fluoride content of urine must be well above 10 ppm to indicate current consumption of fluoride in damaging amounts, and the fluoride content of the metacarpus must be above 4,000 ppm to indicate an accumulated amount that would have any effect other than slight mottling or wear of the incisor teeth.

23. Neeley, K. L., and Harbaugh, F. G. (Texas Technological College, Lubbock): EFFECTS OF FLUORIDE INGESTION ON A HERD OF DAIRY CATTLE IN THE LUBBOCK, TEXAS, AREA. Journal of the American Veterinary Medical Association 124:344-50 (May), 1954.

SUMMARY: The ingestion by cows of feed and water containing fluoride in amounts of 235 milligrams daily for 3 years and 766 milligrams for the next 3 years did not affect milk and butter production and breeding efficiency, and caused no lesions or signs other than slight mottling and wear of teeth.

Forty cows in the Texas Technological College dairy herd, born and raised in Lubbock County, that had completed 2 or more lactations, were selected for the study. The fluoride content of the water supply of the area averages 4 to 5 ppm. By computation of average weight of the cows and average milk production, the average fluoride intake from feed and water for 3 years prior to September 1949 was calculated to have been 0.52 milligram (mg.) per kilogram of body weight per day (or 235.31 mg. daily for a 1000-pound (lb.) cow). Beginning September 1, 1949, the management of the herd was changed and a commercial concentrate feed (with 100 ppm fluoride) replaced the earlier used mixture, increasing the fluoride intake to approximately 1.69 mg. per kilogram of body weight per day (or 765.95 mg. for a 1000-lb. cow). Dental lesions (mottling, staining, and abnormal wearing) were distinctly evident and appeared to be more severe on the incisors which were being formed at the time of higher fluoride intake. The dental changes are illustrated in 4 color plates. No skeletal lesions, stiffness, diarrhea, or elongated hoofs were found that could be attributed to the ingestion of excessive fluoride. Only 1 cow definitely affected by dental lesions was killed, since the cows exhibiting the most extensive dental lesions were the most valuable and, therefore, were not available for slaughter and tissue analysis. The tissue specimens from this cow showed the following fluoride contents (analyses by Wisconsin Alumni Research Foundation): urine, 2.5 ppm; heart tissue, 2.7 ppm; kidney tissue, 4.3 ppm; metacarpus (68.05% ash), 2,695 ppm. The complete production and breeding record for each cow was examined and summarized. The milk and butterfat production was markedly increased concurrently with the high fluoride intake, probably because of improved methods of management. The breeding efficiency of 2 services per calf, for 40 cows that varied in age from 2 to 12 years, was above average of that of dairy herds in the United States.

The results are in agreement with the suggestion that cattle can ingest 1 mg. fluoride per kilogram of body weight per day with no ill effects, except for a possible slight mottling and wear of the teeth.

24. Largent, E. J. (University of Cincinnati, O.): METABOLISM OF INORGANIC FLUORIDES. In: Shaw, J. H., Editor: Fluoridation as a Public Health Measure. Washington, D.C., American Association for the Advancement of Science, 1954, pp. 49-78.

SUMMARY: A high calcium diet depressed to a certain degree the absorption of fluoride when relatively high doses of fluorides were fed to dogs for several years.

Both experimental animals and human experimental subjects have been used in investigations in which it was learned that fluoride is readily absorbed into the circulating blood. Analytical difficulties have hindered the collecting of data relating to exact concentrations of fluoride in the blood. After entering the blood stream, much of the fluoride is excreted in the urine, a part of it is stored in the bones and varying amounts may be eliminated through the skin. Fluoride eliminated in the urine can be measured easily and reliably, and considerable data on urinary fluoride excretion are available in published reports. When the ingestion of fluoride is abruptly decreased to a small fraction of an earlier higher level ingested over a long time, stored fluoride is mobilized and lost from bone provided the low level of intake is maintained. Therefore, high urinary fluoride concentrations will continue for a time until finally the urinary levels will again correspond to the level of ingestion.

A high calcium content in many commercial animal foods may reduce absorption of fluoride. In unpublished experiments, 3 littermate female dogs were maintained on a dehydrated animal food containing 3% calcium. When 2 years old, 2 of the dogs then received in tablet form sodium fluoaluminate or sodium fluoride at 65 milligrams (mg.) of fluoride per day for 4.5 years. The urinary fluoride excretion of the sodium fluoaluminate dog was 4.6 to 11.1 mg. per day (18.5 to 29.6 ppm) and the fecal, 13.1 to 57.2 mg. per day; of the sodium fluoride dog, 16.3 to 22.5 mg. per day (34 to 81.4 ppm), and fecal, 5.3 to 44.4 mg. per day; of the control, 0.14 to 1.4 mg. per day (3.3 to 5.6 ppm), and 0.8 to 6.8 mg. per day, respectively.

Although the abnormally high urinary fluoride concentrations indicated considerable absorption, the absorption was not so complete as might have been expected from the ingestion of sodium fluoride. This is attributed to the effect of high calcium in food. Fluoride analyses of the soft tissues showed values ranging from 0.03 (in liver) to 1.12 (kidney) and 1.18 ppm (lung) for the sodium fluoaluminate dog; from 0.03 (liver and muscle) to 3.01 ppm (kidney) for the sodium fluoride dog; for the control, 0.13 (muscle) to 0.97 ppm (brain). Femurs and ribs contained 1,320 and 2,010 ppm; 3,020 and 3,000 ppm; and 230 and 380 ppm, respectively. No evidence of changed radiopacity in any of the bones was ever observed.

[EDITORIAL COMMENT: This essay presents a comprehensive review of papers in the literature, as well as previously unpublished work by Largent and colleagues. The abstract above includes some of these new data.]

25. Carlson, C. H., Armstrong, W. D., Singer, L., and Hinshaw, L. B. (University of Minnesota, Minneapolis): RENAL EXCRETION OF RADIOFLUORIDE IN THE DOG. American Journal of Physiology 198:829-32 (Apr.), 1960.

SUMMARY: Injected fluoride is rapidly removed from the blood and through the kidney of the dog. A larger proportion of the cleared fluoride appears in the urine than is the case for chloride.

Since radiofluoride injected intravenously into an intact animal is rapidly sequestered in the skeleton and, with renal excretion, results in a rapid decline of plasma radiofluoride, the dogs used in these experiments were prepared so as to remove a considerable part of the skeleton from contact with the circulation. A saline solution of 30 to 90 million counts of radiofluoride and creatinine was infused continuously to 10 such dogs (renal-venous-return preparations) after a priming dose of 50 milligrams (mg.) creatinine per kilogram of body weight; increased urine output was effected by adding glucose.

Three of the dogs received up to 750 mg. of stable fluoride as sodium fluoride in the solution containing radiofluoride, and 3 were given 1 mg. chlorothiazide per kilogram during a portion of the experiment. The animals that received carrier-free fluoride infusions excreted urine with a mean radiofluoride concentration 3.4 to 14.5 times that of the plasma. The urine-to-plasma concentration ratio obtained with animals given a load of stable fluoride was 13.5 to 29.6. An increased urine volume resulted in a decreased tubular reabsorption of fluoride and the clearance was increased. Chlorothiazide increased radiofluoride excretion but decreased the urine concentration. The radiofluoride clearances were always less than the creatinine clearances but were 7.8 to 179 times the chloride clearances. The effect of chlorothiazide was to decrease the ratio of fluoride to chloride clearance by increasing chloride clearance more than fluoride clearance.

In discussing the results, it is concluded that the kidney is well able to discriminate between fluoride and chloride with the former having a clearance several times greater than the latter even though fluoride is present in plasma in amounts of micromoles per liter. Furthermore, the fluoride ion can be concentrated in the urine at least 100 times more effectively than the chloride ion.

The fact that fluoride clearance was never seen to be greater than creatinine clearance does not exclude the possibility of tubular secretion of fluoride.

[EDITORIAL COMMENT: This study and those of P. S. Chen, Jr., and associates: "Renal Clearance of Fluoride," Proceedings of the Society for Experimental Biology and Medicine 92:879-83, 1956, and by C. H. Carlson, et al. (Abstract No. 60) on renal clearance in man, all show that fluoride is cleared from the plasma by the kidney more rapidly than is chloride, and that a larger proportion of the cleared fluoride appears in the urine than is the case for chloride.

The use of radioactive fluoride has permitted a precise measurement of the course of fluoride from the blood plasma to the kidney, with subsequent excretion into the urine and final elimination from the body.]

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 1, 2, 3, 4, 5, 7, 37, 40, 52, 60, 61, 67, 71, 78, 87, 89, 132.

4. METABOLISM OF FLUORIDE IN MAN

The Health of Populations Using Water Containing Fluoride

The most remarkable single factor in the history of research into the effects of the absorption of fluoride is the fact that nature herself has provided ample opportunity for the study of its metabolism in man at various levels of intake. Extensive medical examinations and epidemiologic studies have been done of populations residing in cities in which the drinking water has been fluoridated to the optimum level, and of populations residing in regions where high levels of fluoride occur naturally in water. In addition to this, fruitful investigations have been carried out in the laboratory with human subjects ingesting various fluorides in much higher quantities than are essential for good dental health.

The publications included in this section have been selected from a volume of individual reports on the basis of their thoroughness and significance. Included here also are the endorsements of fluoridation by national and international health organizations. Only a few of the resolutions and reports are listed separately; others are included by name in Abstract No. 80. It is very evident that approval of controlled fluoridation of public water supplies by these organizations came as a result of careful study of the scientific literature and of the evidence that no harmful effects are caused by the daily use of water to which fluoride has been added to the optimum level.

A. INVESTIGATIONS OF THE HEALTH OF POPULATIONS AND EXPERIMENTS WITH HUMAN SUBJECTS

26. Evans, R. J., and Phillips, P. H. (University of Wisconsin, Madison): THE FLUORINE CONTENT OF THE THYROID GLAND IN CASES OF HYPERTHYROIDISM. Journal of the American Medical Association 111: 300-2 (July 23), 1938.

SUMMARY: No correlation was found between the fluoride content of the thyroid, its iodine content, basal metabolic rate, and the fluoride content of drinking water.

Portions of thyroid glands obtained from 40 hyperthyroid patients from various parts of Wisconsin, 22 of whom had received iodine therapy prior to surgery, were analyzed for fluoride. Fluoride was found in the gland in widely varying amounts ranging from 1.5 to 95 ppm (in the dried samples) or from 0.005 to 2.6 milligrams (mg.) of fluoride in the extirpated portion of the gland. The iodine content varied from 0.02 to 0.41% (0.9 to 88.2 mg. in the extirpated gland). No correlation was found between the fluoride content of the gland and either the patient's basal metabolic rate or the iodine content of the gland. Moreover, no relationship was observed between the amount of fluoride in the gland and the fluoride content of the potable waters in the areas where the patients lived. Five of the six thyroids with fluoride content of more than 20 ppm were from patients having a basal metabolic rate of +31 or more; this tends to refute the concept that fluoride may act to lower the metabolic rate. The data provide no evidence that fluoride plays any part in human hyperthyroidism.

[EDITORIAL COMMENT: The upper concentration of fluoride in the thyroid gland is higher than has been reported more recently. In an analysis of the tissues of 41 autopsied cases, R. A. Call ("Summary of Histopathologic and Chemical Findings, with Respect to Fluoride. A Survey in Utah County, Utah," A. M. A. Archives of Industrial Health 21:341-2, 1960) found the fluoride content of the thyroid to range from 1.67 to 15 ppm, with an average of 5.19 ppm of dry, fat-free tissue. The exposure to fluoride is not stated in this paper.]

27. Hodges, P. C., Fareed, O. J., Ruggy, G., and Chudnoff, J. S. (University of Chicago, Ill.): SKELETAL SCLEROSIS IN CHRONIC SODIUM FLUORIDE POISONING. Journal of the American Medical Association 117:1938 (Dec. 6), 1941.

No cases of generalized sclerosis were observed among 86 inhabitants of Kempton, Ill. (7.5 to 71 years of age), where the fluoride content of the water was 1.2 to 3 ppm, and the exposure to fluoride ranged up to 61 years, or among 31 inhabitants of Bureau, Ill. (18 to 78 years of age), where the water contained 2.5 ppm fluoride, and the length of exposure was from 18 to 68 years. In all cases, X rays were made of the pelvis and lower part of the lumbar spine; in some cases, of other parts of the skeleton as well. The films were examined as the work progressed, and a provisional diagnosis was rendered. Subsequently, all films from both communities, together with films of control subjects made with the same equipment, were submitted to a group of radiologists and orthopedic surgeons.

This study had been preceded by surveys in which the typical mottling of dental enamel of high-fluoride areas had been demonstrated.

28. McClure, F. J. (National Institute of Health, Bethesda, Md.): DOMESTIC WATER AND DENTAL CARIES. III. FLUORINE IN HUMAN SALIVA. American Journal of Diseases of Children 62:512-15 (Sept.), 1941.

SUMMARY: The fluoride content of normal saliva is about 0.10 ppm, and is not increased appreciably by fluoride contained in water up to 1.8 ppm.

The fluoride content of saliva specimens obtained from 10 normal adults in Washington, D.C., and vicinity, where the water contained no fluoride, averaged about 0.10 ppm, ranging from less than 0.10 to 0.14 ppm, while that of specimens from 11 children in Amarillo, Texas, where the fluoride content of water is 3.8 to 4.0 ppm, ranged from 0.13 to 0.24 ppm. Pooled saliva specimens collected from groups of 40 to 200 white school children in various cities where the drinking water contained from 0.0 to 1.8 ppm showed no consistent effect of the level of fluoride in the drinking water on the fluoride content of human saliva (the latter ranged from less than 0.10 to 0.16 ppm), but indicated that normal saliva contains about 0.10 ppm. An increased amount of fluoride in the saliva did not appear to be responsible for the observed difference in caries rates in the cities studied.

29. McClure, F. J. (National Institute of Health): NONDENTAL PHYSIOLOGICAL EFFECTS OF TRACE QUANTITIES OF FLUORINE. In: Moulton, F. R., Editor: Dental Caries and Fluorine. Washington, D. C., American Association for the Advancement of Science, 1946, pp. 74-92.

SUMMARY: Waterborne fluoride is largely eliminated in the urine, and the body has adaptive powers to fluoride ingestion by increasing elimination when intake is increased. No bone abnormalities or increased fractures, disorders of kidney function, or any other abnormalities aside from mottling of dental enamel occur from the ingestion of water containing fluoride in concentrations up to 6 ppm.

Domestic waters containing fluoride represent the most extensive exposure to fluoride among human populations. Normal mixed diets, aside from drinking water, provide approximately 0.3 to 0.5 milligram (mg.) of fluoride daily, while extreme variations of fluoride content are found in domestic waters — from nil to more than 15 ppm. As clinical and experimental evidence has shown that the dental and skeletal tissues retain and are particularly sensitive to fluoride, it is necessary to consider: (1) the quantity and the continuity of exposure to fluoride; (2) the ability of the body to eliminate fluoride, thus preventing excessive deposition of fluoride in body tissues; (3) the threshold limits of fluoride tolerated by skeletal tissues as measured in terms of impairment of skeletal function.

The author made an extensive survey of the concentrations of fluoride in the urine of boys, 15 to 17 years old, and of young selectees of the U. S. Army (more than 1,900 specimens), relating these concentrations to the fluoride content of their domestic water supplies, ranging in 18 localities from 0 to 5.1 ppm. (The report was published by F. J. McClure and C. A. Kinser: "Fluoride Domestic Waters and Systemic Effects. II. Fluorine Content of Urine in Relation to Fluorine in Drinking Water," in Public Health Reports (U. S.) 59:1575-91, 1944.) Where the domestic waters were free of fluoride, the urinary fluoride averaged 0.3 to 0.4 ppm; as the fluoride content of water increased, the urinary fluoride also increased, so that waterborne fluoride in concentrations up to 4 to 5 ppm is largely eliminated in the urine. The urinary fluoride response was evident with concentrations of fluoride as low as 0.5 ppm in drinking water, indicating little tendency for even this small quantity to remain in the body. The metabolism of fluoride as ingested in most domestic fluoride waters seems to be a normal function of the human body and characterized by a condition approaching metabolic equilibrium.

The same pattern of excretion of fluoride was seen also in boys before and after fluoridation of the Grand Rapids water supply. The average urinary fluoride of 264 samples from boys 12 to 17 years old was 0.2 ppm before fluoridation; a little over a month after fluoridation began, 315 samples from 12- to 17-year-old boys averaged 0.65 ppm, and from 120 boys 6 to 12 years old, 0.61 ppm.

In order to study the metabolism of fluoride and especially the levels at which retention occurred after ingestion of different compounds and amounts, 5 men, 19 to 24 years old, spent 8 hours each day of a 5-day test period in experimental chambers maintained either under "comfortable" conditions (temperature 84 to 85°F., relative humidity 49 to 52%) or under "hot-moist" conditions (100 to 101° F., relative humidity 66 to 70%). Supplements of 3 mg. of fluoride per day were ingested in the form of sodium fluoride, calcium fluoride, synthetic cryolite, bone meal, and drinking water containing 1.9 ppm fluoride from Galesburg, Ill., so that total fluoride ingested daily was from 3.5 to 6.03 milligrams. Urbana water (fluoride-free) supplied additional water requirements. Conclusive evidence was obtained that sweat and perhaps insensible perspiration account for an appreciable loss of fluoride from the body: 0.5 to 1.8 ppm was found in the sweat during the weeks of the experiment (28 weeks), and one week after its termination, 0.4 to 0.6 ppm. The results showed that (1) absorption of fluoride from bone meal, cryolite, and calcium fluoride (in food) was considerably less than from Galesburg water or from sodium fluoride in food or water, so that absorption depends largely upon the solubility of the supplement, and in the case of calcium fluoride, upon whether it is ingested in food or water; (2) elimination of fluoride in urine and sweat was practically complete when the quantities absorbed did not exceed 4 to 5 mg. daily, and no significant retention occurred when the total fluoride ingested did not exceed 4 to 5 mg. daily. (The full report by F. J. McClure, H. H. Mitchell, T. S. Hamilton, and C. A. Kinser, "Balances of Fluorine Ingested from Various Sources in Food and Water by Five Young Men. Excretion of Fluorine Through the Skin," was published in the Journal of Industrial Hygiene and Toxicology 27:159-70, 1945. In addition, in the full report it is stated that at the end of the experiments, 4 of the men who had ingested fluoride in these quantities for 21 to 26 weeks received thorough clinical and X-ray examination of teeth and surrounding tissues. The results showed nothing that could be associated with the experiments. Urine examinations for albumin, sugar, and blood were negative; red cell counts exceeded 5 million; there was no localized sweat dermatitis, and there were no subjective complaints.)

The experimental and clinical data by others are discussed. As a result of all of these studies, it is evident that all normal skeletal tissues contain certain minimum quantities of fluoride; that there is reason for assuming adaptive powers of the organism to fluoride ingestion, so that when greater quantities of fluoride are ingested, a considerably greater percent is eliminated from the body; that fluoride stored in skeletal tissues is depleted when high exposure has ceased, so that the hazard of cumulative toxic bone fluorosis is minimized. Therefore, the bony tissue and the kidney particularly function as defense mechanisms against toxic quantities of fluoride.

The factors affecting fluoride retention and skeletal tolerance of fluoride are discussed on the basis of reports of animal experiments, and of observations in industry and in high-fluoride regions. There is a strong probability that a "normal" increase of fluoride occurs in skeletal and dental tissue; for this reason the age of individuals furnishing samples for analysis must be known. Peirce had suggested that the fluoride content of skeletal tissue may increase 8 to 10 times above an assumed "normal" (0.02 to 0.03%) without signs of abnormality of bone. Further studies concerning this are needed, bearing in mind an increase of bone fluoride with age in connection with physiologic aging of bone.

Because of reports of bone abnormalities resulting from high fluoride exposure in industry, in India, North and South Africa, although none were found in endemic areas of high-fluoride waters in the United States, the author examined the bone-fracture experience, height and body weight of 1,450 boys, 15 to 17 years old, and 1,600 young selectees with continuous residence in areas whose waters contain fluoride from 0 to 4 or 5 ppm. In addition, physical examination records of 1,000 men from areas with fluoride in water from 0.5 to 5 and 6 ppm, processed at the Lubbock, Texas, Induction Center, were examined. No differences were found between men who had used fluoride-bearing water and those who came from fluoride-free areas. The total number of fractures was 20 to 25 per 100 boys, or men, with a uniform incidence of 14 to 18.5 arm and leg fractures per 100 school boys. (The full report was published in Public Health Reports (U. S.) 59:1543-58, 1944.)

The relation of fluoride and effects on kidney was also investigated. Urinalyses were done on a number of men residing in the West Texas Panhandle where fluoride ranges up to 5 to 6 ppm in the domestic water. Occult blood, albumin and glucose were no different in urine specimens of 101 men from this area than in 394 samples from men from fluoride-free areas.

Animal experimentation using high concentrations of fluoride has suggested a number of other effects such as impairment of calcification and of thyroid function. However, at average quantities ingested from most fluoride-bearing waters, these effects have not been seen. The first specific sign of fluoride injury to the child is the appearance of hypocalcified enamel, or mild mottled enamel; this, however, does not appear in endemic proportions among large population groups, provided the fluoride concentration of the drinking water does not exceed 1 ppm.

The conclusion is that it is highly improbable that prolonged ingestion of fluoride in water at a concentration of 1 ppm will bring about adverse physiologic effects; also it is highly improbable that there is other impairment of body function when the concentration of fluoride in the water is below that necessary to produce the dental lesion.

30. Harrison, M. F. (Otago Medical School, Dunedin, New Zealand): URINARY EXCRETION OF FLUORINE IN SOME NEW ZEALAND SUBJECTS. British Journal of Nutrition 3:166-70, 1949.

SUMMARY: The consumption of tea by New Zealand adults increased the urinary elimination of fluoride in amounts correlating with its intake.

The influence of the consumption of tea, which has a high fluoride content, on urinary excretion of fluoride was studied. Samples of urine collected over 24 hours from 51 subjects showed a mean daily excretion of 0.49 milligram (mg.) of fluoride or 0.33 ppm. There was a correlation between consumption of tea and excretion of fluoride. In a second experiment, 24-hour collections of urine were made from 28 subjects after omission of tea from the diet for 7 days; a further collection was made after 7 days with tea included. The mean daily excretion of fluoride without tea was 0.27 mg. or 0.18 ppm; with tea, 0.52 mg. or 0.33 ppm. The combined results of both experiments showed that the mean daily fluoride excretion of 79 subjects whose diet included tea was 0.50 milligram. The rate of excretion was the same for both sexes.

It is concluded that tea is a major source of fluoride in New Zealand, where the water supplies contain only a small quantity of this element (0.05-0.3 ppm) and the consumption of tea is high. The author points out that in New Zealand tea is not considered to be desirable as a beverage for children, and in general they are not given it at an early age. In view of this, and the above experiments, human skeletal tissues in New Zealand do not acquire any considerable quantity of additional fluoride from tea.

31. McClure, F. J., and Likins, R. C. (National Institute of Dental Research): FLUORINE IN HUMAN TEETH STUDIED IN RELATION TO FLUORINE IN THE DRINKING WATER. Journal of Dental Research 30: 172-6 (Apr.), 1951.

SUMMARY: As compared with teeth of persons living in fluoride-deficient areas, the teeth of those continuously ingesting water containing around 1 ppm fluoride have a higher fluoride content; this is associated with a marked reduction in dental caries. At this level, dental fluorosis is not a problem.

In an earlier publication (Journal of Dental Research 27:287-98, 1948), McClure reported that there were no differences in the fluoride content of enamel and dentin of sound versus carious teeth and that fluoride differences between individual teeth would not explain the presence or absence of caries. He suggested that there was reason to believe that an unusual dietary (particularly waterborne fluoride) exposure during the formative tooth life may increase the fluoride content of the entire dentition which would account for an overall reduction in the dental caries experience.

In this study, noncarious and carious teeth from many individuals from various regions in which the drinking water contains from 0 to 7.6 ppm fluoride, were analyzed for the fluoride content of dentin and enamel. The conclusions based on the results are: The teeth of individuals continuously exposed to drinking water containing 0 to 0.3 ppm fluoride may be expected to contain approximately 0.0100% fluoride in the enamel and 0.0240% fluoride in the dentin. A near dental-optimal quantity of fluoride in Aurora, Ill., drinking water (1.1 to 1.2 ppm) resulted in 0.0133% fluoride in the enamel and 0.0385% fluoride in the dentin; therefore, an increase of 30% in the enamel and 60% in the dentin. These additional quantities of fluoride in dentin and enamel are associated with a marked reduction in the dental caries experience, but dental fluorosis is not an endemic health problem among such teeth. As the fluoride content of the drinking water increased above 2.5 ppm, the fluoride content of the dentin and enamel also increased.

32. Cox, G. J., and Nathans, J. W. (University of Pittsburgh, Pa.): A STUDY OF THE TASTE OF FLUORIDATED WATER. Journal American Water Works Association 44: 940-2 (Oct.), 1952.

SUMMARY: Not one in 1,000 persons can detect sodium fluoride in distilled water by the ionic effect at 1 ppm.

The ability to distinguish a given solution, ranging from 2.4 to 750 ppm sodium fluoride from distilled water by any method of tasting was tested on 187 third- and fourth-year dental students. A total of 1,107 tests of 11 unknowns, or a total of 12,177 single comparisons with distilled water were performed. A solution containing as little fluoride as 2.4 ppm could be detected through the effect of the ions of the salt. However, the most successful taster failed repeatedly to detect fluoride at a concentration of 1.8 ppm. The mechanism of detection is called the ionic effect. The probability has been computed that not one in 1,000 persons can detect sodium fluoride in distilled water by the ionic effect of fluoride at 1 ppm.

Eight of the most successful tasters were tested for ability to recognize the presence of sodium chloride, potassium chloride, potassium fluoride, sodium thiocyanate, ammonium thiocyanate and sodium and potassium formates in distilled water in a concentration equivalent to 18 ppm fluoride. With the exception of a disagreeable "sulfur" taste from ammonium thiocyanate, taste sensations similar to tasting sodium fluoride solutions were reported. More errors were made, however, with the potassium salts, indicating that the sodium ion contributed mainly to the taste sensations of the subjects. The studies indicate that palatability of water is due to subthreshold sensations of salts or to the ionic effect.

[EDITORIAL COMMENT: It should be noted that in these experiments distilled water was used as the solvent, rather than a municipal drinking water which routinely undergoes treatment with various chemical substances; even a domestic well water, by virtue of a possibly high mineral content, might have a taste of its own.]

33. Demole, V., and Held, A. J. (Lausanne, Switzerland): Fluor et santé générale. Etat de santé de la population autochtone et immigrée du village de Sembrancher. (FLUORINE AND GENERAL HEALTH. THE HEALTH OF THE NATIVE AND IMMIGRANT POPULATION OF THE VILLAGE OF SEMBRANCHER). Schweizerische Medizinische Wochenschrift 83:362-4 (Apr. 11), 1953.

SUMMARY: The health of residents of a city whose drinking water has a fluoride content of 1.4 ppm did not differ from the health of people living in surrounding fluoride-deficient areas. The resistance to dental caries was remarkable.

The health of residents of Sembrancher (population 750), whose drinking water supply with 1 to 1.4 ppm fluoride at its source has served several generations, was studied. A general practitioner who had served the town and its environs for 30 years reported that the health of Sembrancher residents in no way differed from that of people living in the surrounding villages with fluoride-poor waters. With the collaboration of a dermatologist, the authors examined 57 residents, mainly native, hence exposed to fluoride water since before birth, with a few who had moved to Sembrancher during childhood; 34 were from 18 to 67 years of age, the other 23 being children 10 to 16 years of age.

The examination stressed the following: general condition, including course of childhood diseases; frequency and severity of rheumatic conditions (many aged persons with above-normal degree of spinal mobility were observed); neurologic and endocrinologic examinations; dermatologic conditions; dental examinations. There was marked resistance to dental caries, but paradental diseases were prevalent. Not a single pathological manifestation described by Spira was observed. Particular attention was paid to otosclerosis. An otologist examined 20 hard-of-hearing adults in Sembrancher. The incidence of otosclerosis was found to be in line with general statistics, even when the possibility of an unusual prevalence of otosclerosis because of hereditary factors was taken into consideration.

To test the possibility of a tolerance to or accumulation of fluoride at optimal quantities of 1 to 1.5 milligrams per day, 4 families who had moved to Sembrancher within the previous 9 to 19 months were examined carefully. No abnormalities attributable to the change in fluoride ingestion were found.

It was concluded that, under conditions considered normal for the country, the concentration of 1 ppm fluoride in drinking water is without any toxic action on the tissues most sensitive to fluoride. In spite of the poor oral hygiene, the resistance to caries among the children and adults of this community is remarkable.

34. Swanberg, H. (Editor, Mississippi Valley Medical Journal, Quincy, Ill.): FLUORIDATION OF WATER AND ITS RELATION TO CANCER. Mississippi Valley Medical Journal 75:125-8 (Sept.), 1953.

The claims made by Perkins in the booklet of The Fluoridation Educational Society, "The Truth About Water Fluoridation," which attempts to use the Grand Rapids statistics of deaths from cancer to help support the claim that fluoridation of the public water in that city "tends to speed up the cancer process and thereby produces earlier deaths in cancer patients," is refuted.

In contrast to the above erroneous interpretation of statistics, according to the official statistics of Grand Rapids, more than 8 years' experience with fluoridation has shown a decrease in the death rates from cancer in Grand Rapids, whereas during this same period there has been an increase in the U. S. as a whole, principally because of the longer lifespan and improved means of detecting the disease. It is emphasized that a few years' statistics concerning a single disease in a single community are not a reliable index; also that care must be exercised in utilizing statistics in an attempt to prove a point.

35. Leone, N. C., Shimkin, M. B., Arnold, F. A., Jr., Stevenson, C. A., Zimmermann, E. R., Geiser, P. B., and Lieberman, J. E. (National Institute of Dental Research and Scott and White Clinic, Temple, Texas): MEDICAL ASPECTS OF EXCESSIVE FLUORIDE IN A WATER SUPPLY. Public Health Reports (U. S.) 69:925-36 (Oct.), 1954.

SUMMARY: The health of residents of a city using water with high fluoride content, as determined in extensive medical examinations, was similar to the health of residents of a city with fluoride-deficient water.

The results of a 10-year Public Health Service study of 116 persons in Bartlett, Texas (fluoride in water 8 ppm until 1952, when an experimental defluoridation unit was installed, reducing it to about 1.2 ppm), and 121 in Cameron, Texas (0.4 ppm), are reported. The participants, aged 15 to 68 in 1943, were chosen at random from persons who had resided in the respective communities for at least 15 years. The average length of fluoride exposure in 1953 was 36.7 years.

In 1943, the investigators took medical histories and gave each participant a medical, X-ray, and dental examination; blood and urine studies were also performed. These were repeated for all in 1953, except for 18 deceased and 10 of the 47 persons who had moved away from the 2 towns. Laboratory blood studies included complete blood counts, a serologic test for syphilis; urine determinations included specific gravity, qualitative albumin and sugar, and microscopic examination. In addition in 1953 rectal and pelvic examinations of most females, and prostate examinations of males; hematocrit, sedimentation rate, blood calcium and, when indicated, acid and alkaline phosphatase, blood sugar, and special hematology, were included. The X rays included anteroposterior views of the dorsal spine, the lumbar spine, and the pelvis with the upper third of the femur. When a question of unusual findings arose, an X-ray survey was made of other selected bones. Consultant service was used when needed. (Characteristics studied included arthritic changes, blood pressure, bone changes, cataract and/or lens opacity, thyroid, cardiovascular system, hearing, tumors and/or cysts, fractures, urinary tract calculi, gallstones.)

No significant differences between the findings in the 2 towns were observed, except for a slightly higher rate of cardiovascular abnormalities in Cameron and a marked predominance of dental fluorosis in Bartlett.

36. McCauley, H. B., and McClure, F. J. (National Institute of Dental Research): EFFECT OF FLUORIDE IN DRINKING WATER ON THE OSSEOUS DEVELOPMENT OF THE HAND AND WRIST IN CHILDREN. Public Health Reports (U. S.) 69:671-83 (July), 1954.

SUMMARY: No indication of adverse effect on the wrist bones or on their growth and development was found in children 7 to 14 years old who had used continuously drinking water with a fluoride content of 3.5 to 6.2 ppm, when compared with children of the same age living in fluoride-deficient areas.

In order to provide additional data on the skeletal effects of exposure to fluoride in drinking water in the United States, the effects of continuous exposure to drinking water containing fluoride in concentrations of 3.5 to 5.5 ppm were investigated.

X rays of the hand and wrist were chosen as the criterion of skeletal development. The fact that the hand is the most reliable single index of ossification of the entire skeleton had been established early in this century and confirmed later. It had also been established that the skeleton of the growing girl is more mature than that of the boy of the same age.

Three groups of children aged 7 through 14 years, living in Lubbock and Amarillo, Tex., and Cumberland, Md., were selected on the basis of continuous exposure to their communal drinking waters, which contained fluoride in the amounts of 3.5 to 4.5 ppm, 3.3 to 6.2 ppm, and 0.1 ppm, respectively. Radiographs were taken of the right hand and wrist of 2,050 children. From these X rays, the skeletal age was assessed and quantitative index of ossification was determined.

The standards used to assess skeletal age were Todd's composite record of skeletal development of Cleveland children from all grades of society, except the destitute. All assessments of the films were made by McCauley and independently rated by one of 3 fellow laboratory workers, then correlated with the original. For the calculation of the ossification index, to determine the developmental status more objectively than by inspectional techniques, that developed by Carter was used. In a test of reliability, after McCauley had determined the ossification ratio from each of 50 radiographs, a laboratory assistant repeated the technique and calculation without knowledge of the results. Both determinations were then correlated.

The distribution of children by age, sex, and community, the percentages of those of Amarillo and Lubbock affected by mottled enamel, mean ossification ratios and skeletal age ratings are tabulated according to age groups. Relatively large numbers of individuals were included in each age group to permit reasonably sound conclusions. The results were further compared with data published in 1936 for University of Chicago normal children. Minor differences occurred in the weighted carpal ossification ratios and in the mean skeletal age ratings for the 4 groups, but these differences seem not to be associated with the exposure to high-fluoride water. The data suggest some tendency toward a uniformly lower osseous development among Lubbock children, particularly girls, but not among Amarillo girls or boys. However, since children in both communities were exposed to fluoride waters, this suggested difference may be related to other factors, such as environmental surroundings, hereditary and ethnic background. On the basis of experiments with animals fed excessively high fluoride doses and observations in industry and in certain endemic areas where exposure to fluoride had been extremely high, it has been learned that the most pronounced nondental effect of such excessive quantities of fluoride is an advanced calcification in both skeletal and ligamentous tissues. Therefore, if any effects were to be found in the present study, they would have been in the nature of hypercalcification and advanced skeletal maturity and bone development. The calcification data do not indicate the occurrence of this characteristic skeletal effect of fluorine.

According to these studies, levels of fluoride of about 3.5 to 5.0 ppm in the drinking water are not sufficient to affect calcification in skeletal tissues which are developing at ages of 7 through 14 years. The presence of 3.5 to 5.0 ppm fluoride in the drinking water also has not altered the long-established sex differences in the rate of development. These results confirm the safety of maintaining the fluoride level of public water supplies at about 1 ppm, by controlled fluoridation, for the reduction of tooth decay.

37. Leone, N. C., Stevenson, C. A., Hilbish, T. F., and Sosman, M. C. (National Institute of Dental Research, Scott and White Clinic, Temple, Texas, and Peter Bent Brigham Hospital, Boston): A ROENTGENOLOGIC STUDY OF A HUMAN POPULATION EXPOSED TO HIGH-FLUORIDE DOMESTIC WATER. A TEN-YEAR STUDY. American Journal of Roentgenology, Radium Therapy and Nuclear Medicine 74:874-85 (Nov.), 1955.

SUMMARY: Only about 10 to 15% of life-long residents, more than 45 years of age, of an area the drinking water of which contained excessive amounts of fluoride — 8 ppm — developed radiologically evident bone changes. These changes were not associated with other physical findings, except dental mottling, and cannot be ascribed to fluoride alone. In fact, ingestion of excessive fluoride may counteract the osteoporotic changes of the aged.

The radiologic findings of the 10-year Bartlett-Cameron study described in Abstract No. 35, are presented. The findings were limited to an evaluation of anteroposterior views of the lumbar spine, sacrum, pelvis, trochanters, and proximal one-third of the femurs. Films made in 1943 were compared with those of the corresponding structures made in 1953. Evaluations were made on the basis of age, sex, activity, study area, and elapsed time.

A limited number of participants from both Bartlett (fluoride in water 8 ppm until 1952) and Cameron (fluoride in water, 0.4 ppm) showed some degree of bone change, but in general these changes were minimal, and there was a larger number with no observable change in the 10-year interval. Histological examination of the bone of a 79-year-old woman with a history of 52 years' residence in the high-fluoride area, who died from a massive cerebral vascular accident shortly after the 1953 examination, revealed no significant changes although chemical analysis showed approximately 6 times the fluoride content (0.6%) of the same bone from individuals from nonfluoride areas. The X-ray examinations in 1943 and 1953 showed a moderate (average) degree of increased bone density with some coarsened trabeculation.

Of the original Bartlett participants, 16 exhibited radiologic bone changes in varying degrees in 1943 that were considered of interest. In 1953, 9 of the 16 showed no further bone changes, 4 showed an increase in density and 3 a decrease in density toward a "normal" appearance. Only one new case of increased density was recorded. Of the cases designated as "increased density," only two could be considered frank abnormalities and none approached the degree described by Roholm and others. In Cameron there were 4 cases of increased density, 2 cases of increased coarsened trabeculation, and 8 new cases of osteoporosis during the 10-year period. During the same period, 4 Bartlett participants showed increased coarsened trabeculation without increased bone density. Increased density occurred predominantly in persons over 45 years of age.

X rays of the cases described below are reproduced. The most pronounced change in terms of increased density and coarsened trabeculation occurred in a 72-year-old white male who had resided in Bartlett for 33 years. The patient exhibited an increase in total density of bone throughout the entire lumbar spine and pelvis as well as a uniform coarsening of the trabeculae. A similar film 10 years later showed no apparent change in the amount or character of this abnormality. Changes which can be designated as typical and which might easily be overlooked are illustrated by a slight but distinct increase in total density and some coarsening of the trabeculae of the bones of the lumbar spine and pelvis of a 71-year-old white male who had been a resident of Bartlett for 59 years. A 59-year-old white female, resident of Bartlett for 39 years, showed increased bone density and coarsened trabeculation in 1943 with a decrease in bone density to a point more closely resembling "normal" bone in 1953. An 84-year-old female resident of Bartlett with known exposure to a high level of naturally occurring fluoride for 50 years and a resident of the high-fluoride area adjacent to Bartlett for the rest of her life (total exposure of 84 years to 4 to 8 ppm fluoride) showed no significant radiologic bone changes. The patient had always enjoyed excellent health and at 84 remained mentally alert and physically active.

X rays of bone of cattle, one from a normal 10-year-old animal and one of an animal of the same age which had ingested very high levels of fluoride (2.2 to 2.5 milligrams per kilogram of body weight daily) for 7 years, are compared. No change similar or comparable to that seen in the fluorosed animal was found in any of the human cases in this series.

From this study it is concluded that ingestion of water containing fluoride up to 8 ppm produces no deleterious bone changes; that the changes seen in X rays occur only in approximately 10 to 15% of those exposed and are slight, often difficult to recognize, bearing no resemblance to the bizarre findings described in some cases of long exposure to cryolite or rock phosphate dust, or to changes attributed by some investigators to excessive fluoride in drinking water. Radiologic bone changes are not associated with other physical findings, except dental mottling in persons who resided in the high-fluoride area during the first 8 years of life, and cannot be definitely ascribed to fluoride alone. They do not necessarily occur even though the fluoride content of the bone may be 6 times that of "normal" bone. There is some indication that the ingestion of excessive fluoride may, on occasion, have a beneficial effect on adult bone as in counteracting the osteoporotic changes of the aged.

38. Levi, J. E., and Silberstein, H. E. (Sinai Hospital, Baltimore, Md.): LACK OF EFFECT OF FLUORINE INGESTION ON UPTAKE OF IODINE^{131} BY THE THYROID GLAND. Journal of Laboratory and Clinical Medicine 45:348-51 (Mar.), 1955.

SUMMARY: The ingestion of water with a fluoride content of 1 ppm does not affect iodine uptake by the thyroid gland.

Fluoridation of the water supply for Baltimore to bring the concentration of fluoride to 1 ppm, using sodium fluosilicate, was initiated in November, 1952. The following tests were done to determine what effect, if any, this rate of fluoride ingestion would have on the function of the thyroid gland.

Thirty volunteer patients at the Deershead State Hospital, Salisbury, Md. (fluoride content of water less than 0.5 ppm), with no history or clinical signs of thyroid deviation and no exposure to fluoridated water (natural or artificial) for a period of at least 6 months prior to the study period were given 50 microcuries of radioiodine (I^{131}) by mouth followed by 24-hour iodine uptake measurements. From the day following the control tracer tests, the subjects were given 4 milligrams (mg.) of fluoride per day as sodium fluosilicate in a single daily dose of 2 ounces distilled water for 3 weeks. The daily dose would have been equal to that ingested in 4 liters of fluoridated water containing 1 ppm fluoride and was estimated to have been slightly in excess of the average daily intake of normal subjects drinking Baltimore fluoridated water. A second tracer test performed on all but one of the subjects after 3 weeks showed no significant changes in the uptake at 24 hours.

Administration of fluoride in 2 daily doses of 2 mg. each to 17 members of the original group was continued for an additional 7 weeks. Repeat radioiodine uptake studies were done on this group at the end of the 10 weeks. Although there was a good deal of variability between the first and third studies, the average difference of -0. 15 counts per second cannot be considered significant, especially since in 10 of the cases there was no essential change. These results indicate that a dilute solution of fluoride of the order of 1 ppm in the drinking water has no effect on radioiodine uptake studies of thyroid function.

[EDITORIAL COMMENT: The availability of radioactive iodine has provided a precise test for the measurement of the function of the thyroid gland, which had not been possible with earlier methods. See also Abstract No. 40.]

39. Steinberg, C. L., Gardner, D. E., Smith F. A., and Hodge, H. C. (Rochester General Hospital, and University of Rochester, N. Y.): COMPARISON OF RHEUMATOID (ANKYLOSING) SPONDYLITIS AND CRIPPLING FLUOROSIS. Annals of the Rheumatic Diseases 14:378-84 (Dec.), 1955.

Increased density of bone observed in X rays occurs in several diseases. This manifestation and other similarities, which were seen in rheumatoid (ankylosing) spondylitis and crippling fluorosis, suggested the importance of presenting a comparison of the two conditions in order to avoid erroneous diagnosis.

Rheumatoid spondylitis occurs universally and is considered to be a variant of rheumatoid arthritis usually affecting males. It begins usually in youth, is painful, and as the disease progresses, a gradual stiffening of the back occurs resulting eventually in a "poker-back" spine. Limitation of the chest expansion also sets in. Characteristics include increase in trabecular pattern seen in X rays, increased density of sacroiliac joints and of ilium and sacrum; calcification of ligaments limited to anterior and lateral spinal column; swollen peripheral joints.

Crippling fluorosis follows the absorption of excessive amounts of fluoride over a long period of time. Osteosclerosis and exostoses are the outstanding findings; sometimes, areas of osteoporosis are also seen. X rays show coarse and blurred trabeculae, and diffuse increased density of bone. Vertebral system and pelvis are first and most severely affected, then ribs and extremities, particularly cancellous bone. Exostoses appear on long bones; there is excessive calcification of tendons, ligaments, faciae, and bones of extremities become thickened.

Because of increased X-ray density of certain lumbar vertebrae, metastatic carcinoma (of the prostate and breast) is also brought into tabular comparison. Aside from showing no peripheral joint involvement and no cortical thickening, this condition is also characterized by an increase in serum alkaline and/or acid phosphatase, whereas no increase in serum phosphatase occurs in the other two.

The most distinguishing feature in crippling fluorosis is increased concentration of fluoride in the urine and in the skeleton, and mottled enamel if fluoride exposure had been excessive during the period of formation of the enamel of permanent teeth. It is noted that when the fluoride concentration in the urine is consistently less than 5 ppm, no radiologically demonstrable osteosclerosis develops.

A case of rheumatoid spondylitis in a man, who had had no known exposure to excessive amounts of fluoride, is presented in detail. His sudden death of a subarachnoid hemorrhage gave the opportunity for the analysis of bone and tissues for fluoride. The fluoride concentrations found were low but normal, or slightly less: the ribs and vertebral specimens contained from 310 to 440 ppm in the ash. Normal ranges had been determined in 1955 for the Rochester area by Smith, Gardner and Hodge to be 400 to 1,300 ppm in ash. The soft tissue adhering to the specimens and marrow contained from 9 to 17 ppm (fresh basis); this was comparable to findings on 5 patients without rheumatoid spondylitis (average of 7 to 26 ppm).

40. Korrodi, H., Wegmann, T., Galletti, P., and Held, H. R. (Medical Polyclinic, University of Zurich): Fluor und Schilddrüse. Beitrag zum Problem der Kariesprophylaxe mit Fluor. (FLUORINE AND THE THYROID GLAND. CONTRIBUTION TO THE PROBLEM OF CARIES PREVENTION WITH FLUORIDE.) Zeitschrift für Präventivmedizin 1, No. 7:285-96, 1956.

SUMMARY: Human subjects ingesting fluoride in doses up to 2-1/2 times the recommended optimum daily intake for periods longer than a year, showed normal ranges of protein-bound iodine of the blood, radioiodine uptake by the thyroid, basal metabolic rate and serum cholesterol, the first two of which are precise, modern tests of thyroid function. Experiments with rats failed to demonstrate any antagonism between fluoride and iodine or between fluoride and the thyroid.

There has been much controversy concerning the effects of fluoride on the thyroid gland. The unproved view that an antagonism between iodine and fluoride exists has led to the use of certain fluorides, such as ammonium fluoride in relatively high doses of 8 milligrams (mg.) per day, and some organic compounds, in the treatment of goiter and hyperthyroidism.

Since effective prevention of endemic goiter with the use of iodine has long been practiced in Switzerland, concern has been expressed that the use of fluoride at a level of about 0.6 ppm or more in iodine-deficient waters might precipitate endemic goiter, in the belief that fluoride inhibits the uptake of iodine by the thyroid gland and increases the elimination of iodine from the body. However, no concrete evidence has been presented that this does occur.

In most of the earlier investigations, particularly those before 1945-1950, highly unreliable methods had been used for the evaluation of thyroid gland disease or function. Generally this was done by palpation of the gland, determination of basal metabolic rate and of serum cholesterol, which are crude compared with modern tests, particularly those using radioiodine uptake and protein-bound iodine.

The authors had been active for several years in the diagnosis and treatment of thyroid gland diseases and have approached the problem of caries prevention with fluoride from this point of view. Some preliminary observations published by them earlier have been extended in the present experiments.

Forty patients with normal thyroid function received sodium fluoride for several months. Regular observation was possible on 15 patients: 10 of them received 2 to 3 mg. of fluoride daily for 6 to 14 months, and 5 received 5 mg. of fluoride per day for 2 to 5 months. Clinical as well as special thyroid function tests failed to reveal any pathologic findings. The data obtained on protein-bound iodine of the blood, radioactive iodine uptake by the thyroid (24-hour values), basal metabolism and serum cholesterol at the beginning and end of the test period showed only negligible deviations within normal limits. No tendency toward an increase or decrease could be seen. These patients had received the maximal dosage of fluoride for caries prevention and up to 2-1/2 times more over periods longer than a year. Therefore, any damaging action on the part of fluoride on the thyroid gland is considered improbable.

In additional experiments, one group of young rats maintained on a standard diet and another group on an iodine-deficient diet, received fluoride in food for 6-1/2 months at doses of 0.005, 0.05, 0.5 or 5 mg. daily. A certain drop in the increase of body weight was seen in the group receiving the higher doses, but no goitrogenic effect of fluoride was observed; the radioiodine uptake was not affected by high fluoride intake either in animals receiving normal food or in those on a low-iodine diet. Increased iodine activity caused by the iodine-deficient diet was clearly evident and was independent of fluoride intake. In another series, 50 and 200 mg. of calcium were given besides fluoride to rats on normal and low-iodine diet. No relation between weight of the thyroid and added fluoride and calcium could be demonstrated, and the radioiodine test did not show any reaction to the added fluoride and calcium. The conclusion was that no antagonism between fluoride and iodine or fluoride and thyroid could be demonstrated in rats.

On the basis of both investigations it is concluded that there should be no hesitation concerning a general use of fluoride for the prevention of dental caries under conditions prevailing in Switzerland.

[EDITORIAL COMMENT: Besides demonstrating the lack of effect by fluoride on thyroid function, this study is of interest in that the serum cholesterol levels of the subjects were not affected by the ingestion of fluoride.

Of pertinence in this respect is also a report by M. M. Black, I. S. Kleiner, and H. Bolker ("The Toxicity of Sodium Fluoride in Man," New York State Journal of Medicine 49:1187-8, 1949), although the dosages of fluoride administered to their cancer patients far exceeded the levels optimal for dental health. Sodium fluoride was administered in doses up to 320 mg. per day for periods of 5 to 6 months to adult and elderly patients and in doses up to 200 mg. daily to leukemic children 3-1/2 to 6 years old. Studies of the following vital functions and criteria revealed no evidence of acute or chronic effect: growth and development in children, eruption of permanent teeth, hematopoiesis, liver function, albumin-globulin ratio, level of cholesterol and sugar in the blood, and kidney function. Postmortem examination in 4 cases showed no parenchymatous degeneration that could be attributed to fluoride toxicity.

In animal experiments, W. Buttner and D. Bixler found that neither the ingestion of fluoride in normal or fatty diet, nor fluoride storage caused changes in the levels of serum cholesterol.]

41. Likins, R. C., McClure, F. J., and Steere, A. C. (National Institute of Dental Research): URINARY EXCRETION OF FLUORIDE FOLLOWING DEFLUORIDATION OF A WATER SUPPLY. Public Health Reports (U. S.) 71:217-20 (Mar.), 1956.

SUMMARY: A decrease in the fluoride content of the drinking water from 8 ppm to 1 ppm, resulted in a decrease in the values of urinary fluoride and in a removal of fluoride previously stored in bone.

The urinary fluoride excretion of 116 white males (7 to 70+ years old) who had used the Bartlett water supply for at least 2 years was determined during a 113-week period following the reduction of fluoride in drinking water from 8 to approximately 1 ppm.

On the day defluoridation was begun, the fluoride content of the urine ranged from 5.0 to 9.2 ppm and averaged 6.5 ppm in children 7 to 16 years of age and 7.7 ppm in adults over 20. After 113 weeks, the average fluoride concentration was 2.2 ppm in children and 2.5 ppm in adults. The fact that urinary fluoride values were considerably higher than would be expected for a corresponding group with no prior exposure to high levels of fluoride indicated that previously stored fluoride was being mobilized. There was no apparent relation between age and urinary fluoride excretion within either group. In comparing the mean fluoride values for the two groups, it was seen that during the first 20 weeks, the urinary excretion in children decreased somewhat less abruptly than in adults. This suggests that during this period the degree of mobilization of skeletal fluoride was somewhat greater in children than in adults.

42. Schlesinger, E. R., Overton, D. E., Chase, H. C., and Cantwell, K. T. (N. Y. State Department of Health): NEWBURGH-KINGSTON CARIES-FLUORIDE STUDY. XIII. PEDIATRIC FINDINGS AFTER TEN YEARS. Journal of the American Dental Association 52:296-306 (Mar.), 1956.

SUMMARY: Medical examination and laboratory tests have shown no differences in the health of children living in Newburgh, where fluoride is added to drinking water, from the health of children of fluoride-deficient Kingston. In addition there were no differences in stillbirths, maternal and infant mortality, nor in death rates from all or specific causes.

In the final series of examinations, 500 of the children enrolled in the study in Newburgh (fluoridated) and 405 in Kingston (fluoride-deficient), excluding those who dropped out for any reason during the course of the study, were seen. These numbers constitute 61.2 and 56.9% of the original group of children at the start of the study who returned for their final examination.

Each child was given a general medical examination by a qualified pediatrician. The results showed no significant differences between comparable age-sex groups in the rate of increase in weight and height. The onset of menstruation in girls was selected as an index of the rate of sexual maturation. The average age at the menarche was 12 years in Newburgh and 12 years 5 months in Kingston. X rays of the right hand, both knees, and of the lumbar spine showed no evidence of increased bone density, nor any significant differences in the rate of skeletal maturation. There was no indication that any of the findings were of pathological significance or that they were in any way related to the use of fluoridated water. In certain of the findings, such as sclerotic epiphysial ossification centers and sesamoid bones of the hand and wrist, a higher proportion of the children in one city was found, while in other findings, such as cortical defects of the knees, the other city had a greater proportion. However, these defects have been found to be of common occurrence and asymptomatic.

Among the laboratory examinations, the hemoglobin levels were closely alike, as were the total erythrocyte and leukocyte counts.

Routine urine analyses showed no significant differences. Because of reports that fluoride causes pathological changes in the kidneys of experimental animals, a special study of the quantitative excretion of formed elements in the urine, using a modified Addis technique, was carried out on 2 groups of 12-year-old boys to detect any possible minimal irritative effects on the kidneys of prolonged use of fluoridated water. (The details are reported in the Journal of the American Medical Association, 160:21-4, 1956. No significant differences were found in the quantitative excretion of albumin, red blood cells and casts between these groups of normally active boys of the 2 cities (in fact, whatever differences were found tended to favor the Newburgh children).) The findings of special ophthalmologic and otologic examinations fell well within the limits expected of any normal group of children of the age studied.

Comparison of the stillbirth and maternal and infant mortality rate for a period starting 5 years before fluoridation and during the 10 years of the study revealed no detectable change in Newburgh. The crude death rates from cancer and cardiovascular-renal disease from 1942 to 1954 show no consistent pattern from year to year; however, it is clear that there has been no increase in deaths from these causes in Newburgh vs. Kingston during the period of water fluoridation.

43. Shaw, J. H., Gupta, O. P., and Meyer, M. E. (Harvard School of Dental Medicine, Boston, Mass.): HIGH FLUORIDE CONTENT OF TEETH FROM COMMUNITIES WITH LOW FLUORIDE WATER SUPPLIES. American Journal of Clinical Nutrition 4:246-53 (May/June), 1956.

SUMMARY: In spite of low fluoride content in the water of two cities in India, the teeth of the residents had high fluoride content and low caries rate when compared with Boston. This may be due to higher consumption of water as well as to the dietary fluoride intake, aside from that contained in water, in India.

A comparison was made of the fluoride content of 161 teeth collected from 52 patients, 26 to 70 years old, in a clinic in Delhi, India, of 75 teeth from 36 patients (25 to 70) in Bombay, India, and of 58 teeth from 35 patients (6 to 60 years) in Boston. The fluoride content of the childhood water supply of the group from Boston was 0.12 ppm, from Delhi 0.25 ppm, and from Bombay 0.04 ppm. As analyzed on two occasions, the fluoride content of the enamel from Boston averaged 40 and 58 ppm; from Delhi 299 and 305 ppm; and from Bombay 184 ppm. That of the dentin from Boston amounted to 85 and 109 ppm; from Delhi 710 and 706 ppm; from Bombay 456 ppm.

There was an obvious difference in caries incidence between the teeth of Indian residents and those of Boston (caries-free permanent teeth of children in various areas of India ranged from 89.6 to 97.1% of total number of teeth). Also, the enamel of the Indian teeth had a very high surface gloss and translucency, and a high percentage had a slight marbled effect resembling very mild mottling as well as large, highly pigmented areas of calculus, due to betel nut chewing. The Boston teeth showed no evidence of mottling, but a characteristically different type of dullness.

It is concluded that only part of the difference in fluoride content between the teeth of Boston individuals and those of Delhi and Bombay can be explained by the probable higher water consumption among the Indian citizens. The average daily water consumption in Madras Province was estimated to be 3 British quarts (3.4 liters), whereas a Boston resident of comparable bodily characteristics consumed 1 liter; therefore, a Delhi resident would consume daily 6 to 8 times as much fluoride, or 0.72 to 0.96 milligram from water, compared with 0.12 milligram by a Bostonian. The remainder of the difference would appear to be due to an additional source of fluoride in the diet, with sea salt (fluoride content, 40 ppm) as a logical possibility, or to a higher rate of absorption and utilization of the ingested fluoride, or to some combination of these two factors.

44. Zipkin, I., Likins, R. C., McClure, F. J., and Steere, A. C. (National Institute of Dental Research): URINARY FLUORIDE LEVELS ASSOCIATED WITH USE OF FLUORIDATED WATERS. Public Health Reports (U. S.) 71:767-72 (Aug.), 1956.

SUMMARY: Within a week after the start of fluoridation, the amount of fluoride eliminated in the urine by adults equaled the concentration in the drinking water. For children, the period of adjustment was considerably longer.

The concentration of fluoride in the urine was determined in individuals of different ages who were drinking water fluoridated to approximately 1.0 ppm with sodium fluosilicate (Montgomery County, Md.) or with sodium fluoride (Grand Rapids, Mich.). Prior to fluoridation, urine specimens contained approximately 0.2 to 0.3 ppm fluoride. In 30- to 39-year-old males (Montgomery County), urinary fluoride levels reached means of 0.7 to 0.8 ppm 1 week after introduction of fluoridated water and

1 ppm after 6 weeks. In male school children aged 5 to 14 (Montgomery County) and 6 to 17 (Grand Rapids), a considerably longer period of time (approximately 3 and 5 years respectively) elapsed before the mean concentration of fluoride in the urine reached that in the drinking water. However, 2 weeks after fluoridation began in Montgomery County, these children excreted a mean of 0.5 ppm, and 0.6 ppm at 10 weeks; in Grand Rapids, 7 weeks after the start of fluoridation the children excreted a mean of 0.6 ppm.

The difference in the response of adults and children during the initial period of exposure to a fluoridated drinking water suggests that the maturity of human skeletal tissue influences its capacity to retain fluoride. In a survey in Aurora, Ill. (where the fluoride content of the water has been about 1.0 ppm from natural sources since 1895), in 1948, the fluoride content of urine specimens from boys aged 8 to 17 varied from 0.8 to 1.0 ppm and averaged 0.9 ppm. Thus, the results of this study do not suggest any essential difference in urinary elimination of fluoride ingested in naturally fluoridated drinking water and the elimination of fluoride ingested in drinking water fluoridated with either sodium fluoride or sodium fluosilicate.

The findings are regarded as evidence that no hazard of cumulative toxic fluorosis is associated with the use of a drinking water fluoridated to contain 1 ppm fluoride.

45. Eley, A. J., Kemp, F. H., Kerley, P. J., and Berry, W. T. C. (Ministry of Health, London, England): THE INCIDENCE OF SPINAL DEFECTS IN HIGH- AND LOW-FLUORIDE AREAS. Lancet 2:712-3 (Oct. 12), 1957.

SUMMARY: No relationship was found in England between ingestion of waterborne fluoride in concentrations up to 5.8 ppm, malnutrition, and spinal defects.

The possible relationship between intake of fluoride and osteochondritis was investigated. A radiographic study was made of the lumbodorsal spines of 328 boys, 11 to 14 years old, from high-fluoride areas (Braintree 1.3 to 3.5 ppm, W. Mersea, Burnham, Harwich 1.5 to 5.8 ppm), and 352 boys from low-fluoride control areas (Bury St. Edmunds 0.1 ppm, Saffron Walden, Stoneleigh, New Malden 0.1 ppm or less). The selection of children was such that the controls resembled as closely as possible the groups examined in the high-fluoride area. Mobile X-ray units were used; the same team operated throughout the areas, using the same technique and equipment. The films were examined "blind" by 3 assessors. No differences in the incidence of spinal diseases or defects were found between the 2 groups.

Twenty-two boys in the high-fluoride areas and 25 in the low-fluoride areas, selected on the basis of possible malnutrition (in view of the National Food Policy of providing increased calcium intake by children) showed no special susceptibility to Scheuermann's disease or other spinal defects. While in the earlier studies (Kemp, F. H., et al., 1942, 1947, 1948) a possible relationship to malnutrition in association with exposure to fluoride was suggested, the present investigation of a larger group of children exposed to much higher concentrations of fluoride (up to 5.8 ppm, compared with 0.3 to 0.8 ppm in Oxfordshire) gives no evidence of a positive relationship between exposure to fluoride, malnutrition, and spinal defects in England.

46. Forrest, J. R. (Ministry of Health, London, England); Alcock, W. (Medical Officer of Health, Watford); Berry, W. T. C. (Ministry of Health); and Longwell, J. (Department of the Government Chemist): SYMPOSIUM ON THE FLUORIDATION OF PUBLIC WATER SUPPLIES. (a) THE DENTAL ASPECT. (b) MEDICAL AND PUBLIC HEALTH ASPECTS. (c) SOME PHYSIOLOGICAL AND CLINICAL ASPECTS OF FLUORIDATION. (d) CHEMICAL AND TECHNICAL ASPECTS. Royal Society for the Promotion of Health Journal 77:344-70; discussion 370-4 (July), 1957.

In (a) J. R. Forrest reviews and discusses the dental conditions in England, preventive measures, historical background of fluoridation, mottled enamel and caries incidence, fluoridation studies in the U. S. and Canada, and fluoridation in the United Kingdom and other countries.

In (b) W. Alcock presents a sound appraisal of the margin of safety of the concentrations adopted for fluoridation of water, and the reported concentrations causing acute poisoning (about 2500 milligrams (mg.) in fatal, and 125 mg. in nonfatal), as well as the chronic (as described by Roholm in cryolite workers — probable intake 15 to 20 mg. fluoride daily), and as reported for the Ft. William area in cattle cropping herbage containing fluoride in concentrations up to 1100 ppm. The publications by Waldbott and the statements by other opponents of fluoridation are criticized and answered.

In (c) W. T. C. Berry discusses the fate of fluoride in the body and the body's reaction to it; the removal of fluoride from the cell mass, uptake by bone, and long-term exchange in bone.

The answer to whether fluoride, by imposing extra work on the kidney, predisposes to, or exacerbates coincidental kidney disease comes from vital statistics. Those of South Shields, W. Hartlepool and Colchester, all having water of about 1 ppm fluoride, show no excess of deaths from nephritis compared with low-fluoride areas. Artificially fluoridated water does not cause a hazard in cases of diseased kidneys so far as excretion of fluoride in normal amounts is concerned according to existing evidence. Possible effects on soft tissue at levels of 1 ppm are considered unlikely.

In (d) J. Longwell deals with the occurrence of fluoride in natural waters and in food. In addition to earlier literature, the results of recent work in the Government Laboratory are mentioned. The urinary fluoride excretion of 2 youths, aged 18 years, on a diet excluding tea or beer was 0.2 to 0.6 mg. per day. When, in addition, 1.2 liters of tea or water containing 1 ppm fluoride was ingested, the urinary fluoride showed an immediate increase, reaching an equilibrium between intake and output of fluoride after about 7 days; 95% was accounted for when a balance had been established (80% having been excreted in urine, the remainder in feces and perspiration). The daily fluoride content of the urine of 36 children in the London area was as follows: 5 to 6 years old, 0.07 to 0.27 mg. (average 0.16); 8 to 9 years, 0.10 to 0.36 mg. (average 0.22); 11 to 12 years, 0.17 to 0.67 (average 0.35) milligram.

The consumption of liquids of various types by 270 people in Willesden, as studied by the Ministry of Health, was found to average daily 1.944 liters for men, 1.415 liters for women, 1.029 liters for children 5 to 14 years old. Assuming that the beer and tea consumed contained 1 ppm fluoride, the probable intake of fluoride daily was calculated to be as follows on water with no fluoride and on water with 1 ppm fluoride, respectively: men, 1.8 and 3.2 mg.; housewives, 1.3 and 2.2 mg.; children, 0.6 and 1.2 milligrams.

Methods for the addition of fluorides to water supplies, control of the level of fluoridation and costs are also discussed.

In the discussion, G. Wynne-Griffith, County Medical Officer of Health, Anglesey, discussed the arguments brought forth by the opposition, and the alternatives to the fluoridation of water. In his own view, for the great mass of the people, "it would have to be water fluoridation or nothing."

D. H. B. Reynolds of the Folkestone and District Water Co., Kent, discussed the engineering problems.

J. H. C. Clarke, County Medical Officer of Health, Kesteven C. C., presented some dental findings resulting from the ingestion of waterborne fluoride in his area, ranging from nil to 4 ppm. Slight to moderate white mottling and marked reduction in caries were seen where the fluoride content was above 0.7 and up to 2.5 ppm. This white mottling, watched in photographs and examinations over 15 years, did not become discolored or change to brown in the course of time. Brown stains were seen only at 4 ppm. The children in these areas are healthy and vital. There is no demonstrable adverse effect on the health of adults: latest mortality rate was 10.5 per 1000, compared with 11.7 for England and Wales and 11.7 for the County of Kesteven; life expectancy is high, and a considerable number of aged people live in the fluoride areas.

N. Parfit, Medical Officer of Health, Abingdon and Faringdon, and R. B. D. Stocker, a dental surgeon of London, regretted the delay in water fluoridation in Great Britain. J. Fletcher of the British Dental Association assured the support of the association, in view of the deterioration in the dental state since 1951.

R. J. Cornish, Professor, College of Science and Technology, Manchester, pointed out that since chlorine and other chemicals are being added to water, the addition of fluoride did not seem to be different from an "ethical" point of view.

47. Stevenson, C. A., and Watson, A. R. (Scott and White Clinic, Temple, Tex.): FLUORIDE OSTEOSCLEROSIS. American Journal of Roentgenology, Radium Therapy and Nuclear Medicine 78:13-8 (July), 1957.

SUMMARY: In only 23 patients among 170,000 X-ray examinations was increased bone density observed. All 23 had lived in areas where the fluoride content of the water ranges from 4 to 8 ppm. No systemic effects and no complaints were related to them.

Independently of the U. S. Public Health Service surveys made in 1943 and 1953 in Bartlett and Cameron, Texas, the authors reviewed the records on file at the Scott and White Clinic in Temple, Texas, for the 11-year period from 1943 to 1953. No cases reported by the U. S. Public Health Service were included.

A roentgenologic diagnosis of fluoride osteosclerosis was recorded on only 23 patients of a total of about 170,000 X-ray examinations of the spine and pelvis of patients from Texas and Oklahoma, where there are more than 320 towns with a water supply containing 0.7 or more ppm fluoride. These 23 patients were given complete clinical examinations, including electrocardiogram in most cases. Laboratory studies included complete blood count, serologic test for syphilis, erythrocyte sedimentation rate, blood urea, and routine urine examination. Bone fractures, which healed promptly, were reported by 4 patients. Clinical laboratory tests yielded no results which could not be explained on the basis of the final clinical diagnosis. Considering the advanced age of most patients, there was no unusual incidence of anemia, arteriosclerosis, arthritis, back stiffness, renal disease or biliary calculi. There was no chemical analysis of bone for fluoride content. The diagnosis of fluoride osteosclerosis was based on bone changes as reported in the literature (Roholm) and own experience with residents of Bartlett, and on cattle. The earliest changes were noted in the pelvis and lumbar spine and consisted of slightly increased bone density and a "ground glass appearance." The skull and extremities showed no changes except for slight roughening in the bones of the forearms or legs of a few patients. Bone changes were found only when the drinking water contained from 4 to 8 ppm fluoride. Each of these patients had lived his entire life in the same fluoride-bearing area in which he was born. Of special interest was the calcification of the sacrospinous and sacrotuberous ligaments. This form of calcification, apparently occurring only in association with other fluoride-induced osseous changes, may be an aid in the diagnosis of fluoride osteosclerosis. There was no cortical thickening or increased bone size.

The bone changes, it was concluded, were minor and harmless since no systemic effects or symptomatology could be attributed to them.

48. Berry, W. T. C. (Ministry of Health, London, England): A STUDY OF THE INCIDENCE OF MONGOLISM IN RELATION TO THE FLUORIDE CONTENT OF WATER. American Journal of Mental Deficiency 62:634-6 (Jan.), 1958.

SUMMARY: There is no relationship between the incidence of mongolism and the ingestion of fluoride-bearing water.

Three communities in England with populations of 55,000 or more were chosen for the study, and designated as the "high-fluoride" areas: South Shields, served by a water supply containing fluoride at 0. 7 to 1. 1 ppm; West Hartlepool, with 1. 9 to 2. 0 ppm; and Slough, with 0. 9 ppm fluoride. Controls were Tynemouth, Carlisle, Gateshead, Stockton, High Wycombe, and Reading, all having water with fluoride content of 0. 2 ppm or less. In addition, areas in Essex County with supplies containing fluoride at 0. 2 to 4 ppm and those with less than 0. 25 ppm were included. The number of mongols (institutionalized or not) born of mothers residing in these areas was determined from the institutions in or serving the area, from death certificates of persons resident there, from records of the medical officers of health, from the personal knowledge of health visitors and others concerned with the welfare of mongols, and finally, the names of the mongols were compared to eliminate duplications. The number of mongols was then compared with the total number of live births among residents in the various areas. Mothers merely coming into the area for delivery were excluded. Although it was impractical to determine for all live births whether the mothers had been resident in the area throughout the entire period of gestation, a check in Slough (fluoride 0. 9 ppm) and its 2 controls revealed that all the mothers had been resident there throughout that time. The period covered was 10 years (1945 to 1954) for the first 2 groups of communities and 1951 to 1955 for Essex.

No relationship was found between the level of fluoride in the water supply, and the incidence of mongolism. Over the 10-year period, 64 mongols occurred in 44,962 live births in the "high-fluoride" areas, and 135 in 87,958 live births in the control areas. The incidence was therefore 1:703 in the "high-fluoride" areas and 1:652 in the low-fluoride areas.

[**EDITORIAL COMMENT:** The findings in Berry's carefully controlled, definitive study are significant, as they are based on accurate records of all birth defects and diseases maintained in Great Britain. The complete register of all such cases in Britain has no parallel in the United States. There is no locale in this country where as definitive a study as this is can be done.]

49. Geever, E. F., Leone, N. C., Geiser, P., and Lieberman, J. (National Institute of Dental Research): PATHOLOGIC STUDIES IN MAN AFTER PROLONGED INGESTION OF FLUORIDE IN DRINKING WATER. I. NECROPSY FINDINGS IN A COMMUNITY WITH A WATER LEVEL OF 2. 5 ppm. Journal of the American Dental Association 56: 499-507 (Apr.), 1958.

SUMMARY: No significant findings were obtained in more than 700 postmortem examinations, which could be related to the prolonged ingestion of water containing fluoride in a concentration of 2. 5 ppm.

Records of autopsy on 728 persons, over 10 years old, who had died in Colorado Springs, Colo. (natural fluoride in water supply, 2. 5 ppm), performed or supervised by the senior author between 1947 and 1953, were examined to study the possible relationships of some pathologic processes impairing health and the ingestion of fluoride. The material included 334 cases with a residency over 20 years, 130 from 5 to 20 years, 188 under 5 years, and 76 whose duration of residence was unknown. The diagnoses were classified and results tabulated according to the major cause of death and contributing causes unrelated to major cause: new growth, accident, leukemia, anemia, tuberculosis, and other diseases by systems (cardiovascular, respiratory, digestive, liver, nervous, and urogenital); and by incidental findings: thyroid disease, gallstones, renal disease, urinary tract stones, liver diseases, peptic ulcer, diabetes mellitus, pancreatitis.

Comparative statistical analyses of the pathologic findings revealed no significant differences that could be related to prolonged residence in the high-fluoride area.

50. Geever, E. F., Leone, N. C., Geiser, P., and Lieberman, J. E. (National Institute of Dental Research): PATHOLOGICAL STUDIES IN MAN AFTER PROLONGED INGESTION OF FLUORIDE IN DRINKING WATER. Public Health Reports (U. S.) 73:721-31 (Aug.), 1958.

SUMMARY: No pathological condition that could be attributed to fluoride ingestion was found at postmortem examinations of persons who had lived in areas with water containing fluoride at 1 to 4 ppm as compared with areas with fluoride-deficient water (less than 0. 5 ppm).

Bone specimens and lumbar intervertebral body joints obtained from necropsies performed on 17 men and 20 women, age 36 to 90 years, with a residency of 10 years or more in Grand Rapids, Mich. (artificially fluoridated to 1 ppm fluoride in water), Colorado Springs, Colo. (fluoride content naturally, 2. 5 ppm), Amarillo, Texas (2. 8 ppm) or Lubbock, Texas (4. 0 ppm) were examined microscopically, and compared with those obtained from 24 men and 9 women, age 21 to 87 years, who had resided in areas with a fluoride level of less than 0. 5 ppm in water. The persons in both groups had died in accidents or from acute diseases not affecting bone structure.

Microscopic changes in ligaments, parosteal tissue and the periosteum were observed more often in the controls than in the fluoride group. Calcifications of marginal tissues, ligaments or tendons, comparable to those described by Roholm, were not seen. Focal calcifications and cartilaginous changes of the periosteum and adjacent tendon or fascia of the iliac crest occurred with equal frequency and intensity in both groups and were regarded as normal; measurements of bone mass in the cortex and medulla as well as the incidence of osteoclasia in bone samples from persons 60 years of age or older were similar in both groups. The lumbar intervertebral body joints showed an increase in osteophytosis in the fluoride group, but the difference almost disappeared when the data were analyzed on the basis of the difference in average age of the 2 groups. Differences in the incidence of architectural abnormalities were insignificant; focal qualitative changes of the bone marrow were of minor importance and appeared more frequently in the controls than in the fluoride group.

In summary, the microscopic examination of the specimens revealed no significant differences between the fluoride-exposed group and the control group that could be related to fluoride intake. Microscopic changes in the bones and joints incidental to aging and due to conditions not related to fluoride were observed in both series.

51. Jackson, D., and Weidmann, S. M. (University of Leeds, England): FLUORINE IN HUMAN BONE RELATED TO AGE AND THE WATER SUPPLY OF DIFFERENT REGIONS. Journal of Pathology and Bacteriology 76, No. 2:451-9, 1958.

SUMMARY: Fluoridation of the drinking water up to 1 ppm does not enable bone to accumulate fluoride to the critical level beyond which skeletal fluorosis may be expected.

The fluoride content was determined in bone samples obtained in England at necropsies from the cancellous part of the sixth rib of persons who had lived a lifetime in a certain area and who had died suddenly or from causes other than bone diseases. (Fluoride was determined by steam distillation procedure of Willard and Winter in apparatus described by Huckabay et al.) Specimens from 42 cases, 12 to 88 years old, from Leeds (practically no fluoride in water) demonstrated a steady increase in fluoride uptake from the age of 12 to 40 years, when the rate of increase lessened until a plateau was reached at age 55, with an approximate mean of 1,900 ppm fluoride.

The lowest value was 250 ppm (age 12) and the highest, 3,940 ppm (age 50). The fluoride content was variable in individual specimens, especially in the age group 40 to 57, where one sample of bone contained 3,940, and another 2,420 ppm, and 5 results lay between 1,140 and 1,540 ppm. Specimens from 27 persons, 38 to 80 years old, from South Shields, where the water contains 0.8 ppm fluoride*, showed the least fluoride at 70 years, 1,470 ppm, and the highest at 80 years, 2,700 ppm; a plateau was established at the age of 50 to 60 years with a mean bone-fluoride content of about 2,500 ppm. Specimens from 56 residents of West Hartlepool (1.9 ppm fluoride in water), 0 to 85 years old, showed the lowest value of 160 ppm fluoride in bone of a day-old baby, and the highest of 5,740 ppm in the bone of a 57-year-old person. The plateau was reached at the age of 55 years at the level of 4,000 ppm fluoride in bone. Individual variations in this group were generally greater than in the samples from the other areas. Out of the 28 cases over the age of 50 years, the bones of 12 contained 4,000 to 5,000 ppm, and those of 5 showed 5,000 to 6,000 ppm.

A comparison of these findings with those obtained in similar studies in the United States suggested the existence of an extra source of fluoride in the English dietary, which is believed to be tea.

In discussing the relationship of the fluoride content of bone with a critical level of bone-fluoride beyond which skeletal fluorosis may be expected to occur, attention is drawn to the differences in fluoride contents of the individual portions of skeletal tissues; hence, precise sampling techniques must be known before comparison is made.

On the basis of the findings, it is concluded that artificial fluoridation of drinking water up to 1 ppm does not enable bone to accumulate fluoride to the critical level; in fact, evidence obtained in Bartlett and Cameron, Texas, suggests that in a temperate zone, as high a concentration of fluoride as 8 ppm in drinking water is below the critical dose.

*[ABSTRACTOR'S NOTE: The value for the fluoride content of South Shields water has since diminished, as noted in Report by Ministry of Health (Abstract No. 85).]

52. Knizhnikov, V. A. (Kazakhstan Institute of Epidemiology, Microbiology, and Hygiene, U. S. S. R.): Vliyanie prirodnykh vod s vysokim soderzhaniem ftora na nekotorye pokazateli zdorov'ya vzroslogo naseleniya. (EFFECT OF THE NATURAL FLUORINE CONTENT IN WATER ON CERTAIN HEALTH INDICES IN THE ADULT POPULATION.) Gigiena i Sanitariya 23, No. 8:18-23, 1958.

SUMMARY: Extensive medical examinations revealed no difference, excepting mottled enamel, between the health of residents of a city in the Soviet Union, where the drinking water contains fluoride in a concentration of 4 ppm, and that of residents of a city, the water supply of which contains fluoride at 0 to 0.9 ppm.

The author expresses the opinion that, although much has been published on the significance of waterborne fluoride for teeth and the skeleton, especially of children, there are but few papers dealing with the effects of excessive or deficient quantities of fluoride on the health of adults. He reviews briefly the investigations of the health of populations ingesting fluoride-bearing waters, as reported by Hagan and Leone for the United States, and by Bartha for Hungary. He mentions also publications by Waldbott who had attributed various symptoms in his patients to the ingestion of water containing fluoride in a concentration of 1 ppm, and states that other investigators did not accept Waldbott's connection of these symptoms with the ingestion of fluoride-bearing water.

Two towns, 70 kilometers apart, in Eastern Kazakhstan, having similar climatic conditions and similar size and type of population, were chosen for investigation. The residents of Shchuchinsk use lake water containing 4 ppm fluoride, with seasonal variation from 3.4 to 4 ppm (monitored over a period of 5 years). Mottled enamel, seen in old people, was proof that water of high fluoride content had been used for a long time. The water supply of Kokchetav stems from ground and artesian wells with 0 to 0.9 ppm fluoride, occasionally lake water containing 0.9 ppm fluoride. (The alizarin-zirconium method modified by the Moscow Institute of Health was used for fluoride determination.) Clinical and laboratory examinations were done in 1955 on 121 men and women, 40 to 85 years of age, and in 1956 on 48 women, 30 to 40 years old, residing in Shchuchinsk; similar examinations were done on 53 women, 30 to 40 years old, living in Kokchetav. Clinical examination of the younger group included oral structures for caries and stomatitis, skin, arterial pressure, nervous system, and hematology. The last two types of tests were not done on the older group.

The results of the investigations were as follows:

Mottled enamel of grade II and III was seen in 17 of 48 women from the high-fluoride town (grade IV was never seen); none was detected in the low-fluoride town. No differences were observed between the two towns as to complaints of sleeplessness, headaches, fatigue, irritability, muscular weakness, urinary disturbances, and pains in bones, joints, or the lumbar region. Nor were differences determined in the occurrence of paresthesia, chronic urticaria, increased salivation or dryness of mouth, increased or decreased sweating, brady- or tachycardia, hyper- or hypotension, and reflexes. In the clinical examination of the older group (high-fluoride), hypertension was found in 12%, or within the expected range.

Hematologic findings (coagulation time, hemoglobin, leukocyte counts) showed no differences between the two towns. Phagocytic activity of the blood was higher in the high-fluoride than in the low-fluoride region. Statistical analysis of records of death over a 10-year period as to causes (congenital malformations, heart disease, cancer, tuberculosis) and of those of reported illness in adults (over 15 years of age) for the years 1953 and 1954 (30,005 reports in high-fluoride and 35,529 in the low-fluoride towns) revealed incidence of both deaths and types of diseases, that had been attributed by some authors to the ingestion of fluoride, to be lower in the high-fluoride than in the low-fluoride town.

It is concluded that, aside from causing mottled enamel, the ingestion of water containing up to 4 ppm fluoride had no detrimental effect on health.

[ABSTRACTOR'S NOTE: In a subsequent publication ("Fluorisierung von Trinkwasser im Lichte einiger neuer Erkenntnisse über die Wirkung von Fluor auf den Organismus. (Fluoridation of Drinking Water in the Light of Some New Data on the Effect of Fluorine on the Organism)," Journal of Hygiene, Epidemiology, Microbiology and Immunology 4, No. 1:6-11, 1960) Knizhnikov reviewed the fluoride investigations of the Institute on populations, human subjects, and on laboratory animals, and stated that fluoridation of drinking water was officially advocated on the basis of these findings. The Chief Sanitary Inspector of Kazakhstan was the first in the U. S. S. R. to authorize provisional directives to start fluoridation in two cities of that state in 1959 and to conduct extensive studies on the effect of this measure on the health of the population.]

53. McClure, F. J., McCann, H. G., and Leone, N. C. (National Institute of Dental Research): EXCESSIVE FLUORIDE IN WATER AND BONE CHEMISTRY. COMPARISON OF TWO CASES. Public Health Reports (U. S.) 73: 741-6 (Aug.), 1958.

SUMMARY: Human bone may contain fluoride in as high concentrations as 5,000 to 6,000 ppm without being adversely affected.

The effect of a prolonged exposure to drinking water containing high levels of fluoride on the chemistry of human bones, and the relation of fluoride to other bone elements, particularly those concerned with calcification, were studied by determining the fluoride, ash, calcium, phosphorus, magnesium, and carbon dioxide contents of bones of a woman (A), 74 years old, who prior to her death caused by a heart attack had lived for 24 years in Washington, D. C. (fluoride in water, 0.2 ppm), and of a woman (B) who died as the result of a cerebral vascular accident at 78 years after 34 years of residence in Bartlett, Texas (fluoride in water, 8 ppm). The concentrations of fluoride in the various bone specimens (dry, fat-free) of Subject A varied from 0.062% in the femur to 0.092% in the calvarium, and of B, from 0.512% in the fibula to 0.653% in the calvarium. Fluoride in the intervertebral cartilage of the 2 women amounted to 0.006% and 0.011%, respectively. Analysis of the other constituents of bone gave some indication that the prolonged use of drinking water containing 8.0 ppm fluoride accounted for an increase in the ash and a slight increase in the calcium content of the skeletal tissues, that is, slight increase in calcification in skeletal tissues.

The absence of any gross or systemic findings, or of any impairment of health or wellbeing, malformation of the skeletal tissues, or malfunction generally in Subject B, as determined by Leone, et al., indicates that human bone may not be affected by the presence of as much as 0.5 to 0.6% fluoride in bone.

54. Steinberg, C. L., Gardner, D. E., Smith, F. A., and Hodge, H. C. (Rochester General Hospital, University of Rochester, N. Y.):

FLUORIDATION OF PUBLIC WATER SUPPLIES AND ITS RELATION TO MUSCULOSKELETAL DISEASES. New England Journal of Medicine 258:322-5 (Feb. 13), 1958.

SUMMARY: There is no relation between the various forms of arthritis and the ingestion of fluoridated water. The fluoride content of bone of arthritic and non-arthritic residents of a nonfluoridated area were similar to that of residents of a fluoridated area.

Eighteen samples of joint and bone tissue (vertebra, femoral condyle, tibia, joint surface, and patella) were obtained either at autopsy or surgery from 14 male and female patients, 29 to 90 years old (mean age 68 years), suffering from various forms of arthritis, and from 1 patient who did not have arthritis. The patients had resided in a fluoridated area of Rochester for periods ranging from 3 years and 5 months to 4 years and 8 months. Fluoride analyses, done at the University of Rochester School of Medicine and Dentistry, showed a fluoride content from 915 to 2, 200 ppm in the ash (mean, 1,374 ppm). A gradual increase in the fluoride levels with age was observed, and a tendency toward higher levels in males than in females of comparable ages. The duration of the exposure to fluoridated water appeared to have very little effect. In earlier studies (1953), the Pharmacological Laboratory of the University of Rochester had analyzed rib and vertebra samples obtained at autopsies from 85 males and 73 females, aged 10 to 90 years, who had had no unusual fluoride exposure and had used throughout life water with a fluoride content of less than 0. 1 ppm. The concentrations ranged from 241 to 2, 223 ppm for men and 217 to 1, 839 ppm for women, clearly indicating the sex difference and increase with age.

It was calculated that at the age of 70 years, a person drinking 1 quart of fluoridated water per day would accumulate in his skeleton not over 3, 000 to 4, 000 ppm. Even if all the extra 1 milligram of fluoride ingested per day were deposited, the skeletal fluoride in 50 years would be 6, 000 ppm, i. e., a concentration that should have no untoward effects.

Fifteen similar bone samples from 11 patients with arthritis and from 2 who had no arthritis (mean age 76 years) residing in a nonfluoridated area of Rochester showed fluoride values from 415 to 2, 590 ppm, or values statistically not different from those of residents in the fluoridated area.

A careful review of the radiograms of both groups, along with the bone fluoride studies failed to reveal any relation between various forms of arthritis and the ingestion of the fluoridated water of Rochester.

55. Zipkin, I., Lee, W. A., and Leone, N. C. (National Institute of Dental Research): FLUORIDE CONTENT OF URINARY AND BILIARY TRACT CALCULI. Proceedings of the Society for Experimental Biology and Medicine 97:650-3 (Mar.), 1958.

SUMMARY: The fluoride content of urinary calculi is relatively high, and does not differ significantly in low- or high-fluoride areas: means of 2, 500 and 3, 700 ppm were found in fluoride-free and 2. 6-ppm areas, respectively. There is no relation between the calcium and fluoride concentrations of these calculi. Very low concentrations of fluoride occur in biliary calculi: 0 to 60 ppm in an area where the fluoride content of water is 2. 6 ppm.

The fluoride (F) content, as well as fat, ash, calcium (Ca), and phosphorus (P), were determined in 33 urinary and 9 biliary tract calculi from persons residing for at least 10 years in low-fluoride areas (Los Angeles, 0. 0 to 0. 6 ppm) or in areas with a high natural fluoride content in water (Colorado Springs, 2. 6 ppm).

The mean content of fluoride, on an oven-dry basis (determined by Willard-Winter, Armstrong, and McClure procedures), of the urinary tract calculi in the low-fluoride and high-fluoride groups did not differ significantly, i. e., 0. 25% and 0. 37%, respectively. Their Ca/P weight ratio varied widely (0. 1 to 45. 7) and was unrelated to the concentration of fluoride, Ca/P:F (3. 3 to 762. 0); no relation was apparent between the calcium and fluoride concentrations, Ca/F (35. 3 to 695. 0).

Nine biliary tract calculi, 2 from persons residing in Amarillo (fluoride in water, 1. 6 to 3. 2 ppm) for an unknown period of time and 7 from Colorado Springs (2. 6 ppm) residents for 2 to 39 years, contained very low fluoride values (0. 000 to 0. 006%, oven-dry basis); fat comprised at least 90% of the calculi, and the ash and calcium contents were very low.

A pooled sample of bile from 4 persons using 1-ppm-fluoride water (Washington) contained 0. 1 ppm. A sample of bile obtained from an ox exposed to high concentrations of fluoride on forage for 4 years, contained 0. 6 ppm fluoride.

The fluoride values of the calculi were compared with 35 bone samples from similar low- and high-fluoride areas (mean residency 20.1 and 30.4 years, respectively). The urinary calculi showed significantly higher mean concentration of fluoride than the bones in both low- and high-fluoride areas; this may be due to higher fluoride in urine than in blood. While the calculi showed no significant increase in fluoride with an increase of fluoride in drinking water, a 4- to 5-fold elevation of fluoride was observed (on oven-dry or ash basis) in the bones from the high-fluoride area. This may be attributed partly to growth and metabolic turnover in bone while the calculi may be thought to be metabolically inert.

[EDITORIAL COMMENT: The differences in the composition of calculi and bone undoubtedly play an important role in the relative abilities of these substances to incorporate fluoride. The concentrations of fluoride in fluid surrounding these materials are vastly different, being much lower in body fluids (mean 0. 16 ppm) than in urine. Although a homeostasis exists in the concentration of fluoride in body fluids, considerable variation in urinary fluoride occurs depending upon the age of the individual, fluoride exposure, the fluoride intake, and urinary volume voided.]

56. Zipkin, I., McClure, F. J., Leone, N. C., and Lee, W. A. (National Institute of Dental Research): FLUORIDE DEPOSITION IN HUMAN BONES AFTER PROLONGED INGESTION OF FLUORIDE IN DRINKING WATER. Public Health Reports (U. S.) 73: 732-40 (Aug.), 1958.

SUMMARY: The fluoride content of bone increases in a linear fashion with increased fluoride intake. At any given level of fluoride intake, the various bones contain similar amounts of fluoride. The fluoride content of cartilage is considerably lower than that of bone. It also increases with fluoride intake, and calcification is not affected by the higher levels found in this study.

In conjunction with the microscopic examination of bones obtained at autopsy from 69 persons (as described in Abstract No. 50) who had used water containing fluoride in concentrations ranging from 0. 1 to 4. 0 ppm for 10 to 87 years, essentially the same bones (iliac crest, lumbar vertebra, and 6th rib) and intervertebral cartilage, showing no significant histologic changes, were analyzed for ash and fluoride. This is the first systematic survey of bone fluoride content of a large number of individuals exposed to fluoride at various concentrations, in contrast to previous reports of bone analyses involving no more than 4 persons exposed to high fluoride levels.

The fluoride content of the bones, which ranged up to 0. 548% on a dry, fat-free basis and 1. 080% on an ash basis, increased in an essentially linear fashion with increase of fluoride in drinking water. No definite relation between fluoride content, age of persons and years of residence was detected. No significant histologic changes were found in the bones examined. The fluoride values for 15 bones from persons who had a malignancy or renal disease were within the variations encountered for others within the same group. While fluoride in cartilage was increased, calcification of the tissue does not appear to have been affected by increased fluoride. The fat content of neither bone nor cartilage was related to the fluoride content of drinking water.

Mean percentages of ash and fluoride in dry, fat-free bones and cartilage were as follows:

Fluoride (F) in water ppm, No. persons, age	Iliac crest		Rib		Vertebra		Cartilage	
	Ash	F	Ash	F	Ash	F	Ash	F
0. 1-0. 4; 23 male, 10 female, mean age, 55. 5; mean, 28 yr. in area 1	57. 4	0. 041	56. 8	0. 050	49. 0	0. 054	4. 8	0. 003
1. 0; 2 male, 3 female, mean age 75. 6; 21. 5 yr. in area 2	61. 2	0. 138	57. 4	0. 139	50. 0	0. 160	3. 9	0. 004
2. 6; 13 male, 14 female, mean age 65. 9; 32. 9 yr. in area 3	59. 7	0. 267	59. 7	0. 257	46. 3	0. 286	3. 8	0. 004
4. 0; 3 male, 1 female, mean age 56; 21. 3 yr. in area 4	59. 9	0. 413	57. 5	0. 398	50. 7	0. 411	4. 2	0. 007

(Areas of residence: (1) Baltimore, Washington, New York City, San Antonio; 5 of this group drank water at 1 ppm F for 2 to 4 years; (2) Grand Rapids; (3) Colorado Springs and Amarillo; (4) Lubbock.)

57. Hagan, T. L. (Division of Dental Public Health, U. S. Public Health Service): EFFECTS OF FLUORIDATION ON GENERAL HEALTH AS REFLECTED IN MORTALITY DATA. In: Muhler, J. C., and Hine, M. K., Editors: Fluorine and Dental Health. The Pharmacology and Toxicology of Fluorine. Bloomington, Indiana University Press, 1959, pp. 157-65.

SUMMARY: The consumption of water with a fluoride content of 0. 7 ppm or more, whether occurring naturally or added in controlled fluoridation, has not affected mortality rates in the United States.

Two earlier studies, relating the presence of fluoride in community water supplies to mortality statistics, are reviewed. The first of these, by the Illinois Health Department, was based on 1940 census and mortality reports (Bulletin, State of Illinois, Department of Public Health, Special Release No. 20, April 1, 1952). Rates of deaths from selected causes and from all causes combined among 4 Illinois communities of over 10, 000 population using water containing fluoride naturally at 0.7 ppm or more were compared with rates in other Illinois cities of like size using fluoride-free water. It was concluded that "mortality experience in Illinois offers little or no support for claims of adverse effects being produced by limited ingestion of fluoride. "

In the second study (Public Health Reports (U. S.) 69:450-4, 1954) the 1950 mortality rates in 32 cities of more than 10, 000 population using water containing fluoride naturally at 0. 7 ppm or more were compared with the rates in 32 nearby cities of the same size using water with 0. 25 ppm fluoride or less. The 1950 rates for deaths from all causes showed no discernible differences. The heart disease mortality rates were higher in 17 of the nonfluoride cities than in the paired fluoride cities; in the other 15 pairs, the fluoride cities were higher than the nonfluoride cities. Nephritis mortality rates were higher in 19 nonfluoride cities and in 13 fluoride cities than in the corresponding paired fluoride and nonfluoride cities. Cancer mortality rates balanced exactly between the fluoride and nonfluoride cities.

The third analysis concerned 5 cities (Grand Rapids, Mich., Sheboygan, Wis., Evanston, Ill., Madison, Wis., and Charlotte, N. C.) before and after controlled water fluoridation was begun (from 1945 to 1949). The populations of these cities were large enough to give stability to comparative mortality data. The 1940 and 1950 mortality statistics for each of these cities were used, as data for intercensal years lack the precision of true counts necessary for such a study. In any study, the general decline in mortality for specific causes, especially infectious diseases and neonatal conditions, and in- and out-migration, must be taken into account. To standardize these factors, the proportion of U. S. population in 1940 and 1950 by race and sex and the specific U. S. mortality rates in these two years by age, race, and sex were first determined. The change in composition of the population by age and sex in each of the 5 cities during the decade was then determined. To the extent that there is a change in population characteristics of a community, there is to be expected a change in mortality in the community. For each of the 5 cities, a comparison was made of the recorded deaths and expected deaths (computation applying the specific age-race-sex mortality rates for U. S. to the counterpart population cohorts in each of the cities examined). A significant change in this ratio from one year to another would have indicated that some variable other than age, race, sex, and declining mortality which had been equated out, had had some influence. For no city was there a significant change in the 1950 ratio of recorded deaths to the expected from the 1940 ratio. Deaths due to motor-vehicle and other accidents and from suicides and homicides were excluded.

These data, therefore, show that water fluoridation has had no effect on the mortality rates in the cities studied.

58. Leaver, R. E., Stein, J., and Ishii, M. (Washington State Department of Health, Seattle): EFFECT OF SODIUM FLUORIDE IN PUBLIC WATER SUPPLY ON PERSONS ON LOW SODIUM DIET. Letter to the Editor. Northwest Medicine 58:347, 350 (Mar.), 1959.

If sodium fluoride or sodium fluosilicate is used in order to obtain a fluoride concentration of 1 ppm in water, the amount of sodium ion added to the water is 1.2 ppm or 0.75 ppm, respectively. Since the normal water consumption ranges from 1 to 2.5 liters per day per person, fluoridation would add to the diet of a person about 1 to 2.5 milligrams (mg.) of sodium per day. This amount is insignificant, considering the fact that a severely restricted low sodium diet allows a patient 250 to 500 mg. of sodium per day, a low sodium diet means 1,000 mg. per day, a mild low sodium diet ranges from 2,400 to 2,500 mg. per day, and the average normal intake of sodium ion from food and water is 3,000 to 6,000 mg. per day.

On the basis of these figures, it is suggested that a person on a restricted salt diet rather be careful about the types of foods he is eating, than be concerned about the sodium ion in the water supply due to fluoridation.

59. Singer, L., and Armstrong, W. D. (University of Minnesota, Minneapolis): REGULATION OF HUMAN PLASMA FLUORIDE CONCENTRATION. Journal of Applied Physiology 15:508-10 (May), 1960.

SUMMARY: The plasma fluoride content of residents of cities using waters with fluoride content of 0.15, 1.0, and 2.5 ppm was similar; it ranged from 0.14 to 0.19 ppm. Residents using a 5.4-ppm-fluoride water had slightly higher plasma fluoride levels, 0.26 ppm. The levels did not vary from the normal in various disease states. All this is evidence that the body is capable of stabilizing the fluoride content of its fluids.

The plasma fluoride content was determined in the blood of residents (20 to 64 years old, mostly males) of the following communities: 16 samples from Rochester, Minn., fluoride in water 0.15 ppm; 18 from both Minneapolis and St. Paul, fluoridated for 11 months and 6 years, respectively (1.0 to 1.1 ppm); 36 from Grand Rapids, Mich., fluoridated for 14 years to 1.1 ppm; 26 from Gettysburg, S. Dakota, natural fluoride content 2.5 ppm; 22 from Lake Preston, S. Dakota, with a natural fluoride content of 5.4 ppm. All Minneapolis-St. Paul donors had resided in their community for at least 3 years with no more than 1 month's absence in any year; all other donors had lived in their local communities for at least 5 years with an absence of no more than 1 month during the previous year.

The samples from the communities with a fluoride content in water up to 2.5 ppm showed a constancy of plasma fluoride values ranging from 0.14 to 0.19 ppm indicating that homeostasis of body fluid fluoride content results at these levels of waterborne fluoride. Intake of 5.4 ppm in water caused a slight but significant increase in plasma fluoride (0.26 ppm). No correlation could be found in any group between the period of residence and the plasma fluoride content.

A study of diurnal variations of the plasma fluoride content in 3 adults drinking fluoridated water showed that regulation of plasma fluoride occurs throughout the day.

In another test, 2 adults each ingested 1 milligram of fluoride as sodium fluoride. No elevation of plasma fluoride content above normal values was observed in 4 samples collected at 20 to 220 minutes after the ingestion.

The plasma fluoride content of 30 Minneapolis-St. Paul hospital patients was the same (mean, 0.16 ppm) as that of the normal residents of these cities. Higher values than normal were found in 3 cases of demineralizing skeletal disease (hyperparathyroidism and multiple myeloma). It is suggested that these high values were a result of the disease and were caused by a net movement of fluoride from the skeleton to the blood. In one case of hyperparathyroidism, the plasma fluoride content decreased by about 50% following the removal of the parathyroid adenoma. One case of carcinoma of the pancreas showed a higher than normal plasma fluoride content, while extremely low values were found in one terminal patient with carcinoma of the lung.

60. Carlson, C. H., Armstrong, W. D., and Singer, L. (University of Minnesota, Minneapolis): DISTRIBUTION AND EXCRETION OF RADIOFLUORIDE IN THE HUMAN. Proceedings of the Society for Experimental Biology and Medicine 104:235-9 (June), 1960.

SUMMARY: Fluoride is rapidly absorbed and almost completely cleared from the soft tissues within 4 hours after ingestion; one-third of it is eliminated in the urine within that time. Hard tissues retain their fluoride. Not more

than 10% of the fluoride ingested is present at any one time in the blood plasma where 72% of the blood fluoride is contained. The concentrations of fluoride of the parotid saliva are always lower than those of the plasma where it ranges from 0.13 to 0.17 ppm.

Since fluoride ion is a trace element and occurs biologically in very small quantities, a radiotracer, radiofluoride at 5 microcuries, was used to label 1 milligram of fluoride (as sodium fluoride) ingested by each of 2 human subjects in 250 milliliters (ml.) of water, to determine its fate in the organism. Each subject drank 250 ml. of water at 1 hour and at 30 minutes before and 30 minutes after ingesting the fluoride solution, then additional water lasting up to 5 hours to permit collection of urine specimens at 10- to 15-minute intervals. Blood samples were taken periodically by venipuncture. The fluoride contents of the plasma of the subjects were 0.17 ppm (3 samples) and 0.13 ppm (5 samples). Maximum plasma radiofluoride concentration was reached within 60 minutes. By calculation, 72% of blood-fluoride was present in the plasma, and using body weight for estimation, not more than 10% of radiofluoride ingested was present in the entire plasma at any one time. The radiofluoride concentrations of parotid saliva were always below those of the plasma. In observing renal clearance of fluoride, chloride and creatinine, fluoride clearance always greatly exceeded the chloride, and increased with urine flow, but was always less than creatinine clearance. Renal tubules in the subjects reabsorbed respectively 51 and 63% fluoride in the glomerular filtrate which indicates a net process of glomerular filtration with a variable amount of tubular reabsorption.

Portable counter observations of the body areas showed that the movement of fluoride from the epigastrium and uptake in and release by the soft tissues occur rapidly (nearly all activity being lost in 4 hours) and that hard tissues retain their fluoride even though plasma activities decreased markedly. One-third of ingested radiofluoride was recovered from the urine within 4 hours.

[ABSTRACTOR'S NOTE: W. D. Armstrong reviews the recent work at the University of Minnesota in "Mechanisms of Fluoride Homeostasis," Archives of Oral Biology 4:156-9, 1961.

In addition to the experiments described in Abstracts Nos. 25, 59, and 60, experiments were done with normal and nephrectomized rats to determine whether kidney injury would change the pattern of fluoride distribution in the tissues. This pattern was not changed, so that the organism still possesses an effective mechanism of fluoride homeostasis. Fluoride was also found to be distributed through a larger volume of body water than was chloride in many tissues when both fluoride and chloride were injected simultaneously, but the distributions were not affected by large variations in the fluoride content of the food on which the animals had been raised.

These investigations show that the body possesses a remarkable ability to maintain a constancy of body fluid concentration in spite of large variations of fluoride intake. These mechanisms of homeostasis are carried out by the kidney, which operates as an effective organ of fluoride excretion, and by the skeleton.]

61. Editorial (H. C. Hodge, University of Rochester, N. Y.): STRONTIUM 90 AND FLUORIDATED WATER. American Journal of Public Health 50:868-9 (June), 1960.

A recent objection to fluoridation by Kerwin (Dental Digest, 1958) capitalizes on the genuine alarm over radioactive fallout from atom bomb tests and the possible ultimate radiation injury by strontium-90. Kerwin suggests that strontium-90 fluoride deposits in the bones of those who drink fluoridated water, thereby increasing the content of the radioactive strontium in bone and consequent danger.

The scientific facts are that (1) strontium-90 is deposited in bone, has a long half-life, and emits radiation. (2) Stable strontium is naturally present in blood and bone, but at a ratio of 1 atom to 2,000 calcium atoms, and in the bone crystals of hydroxylapatite mineral, strontium presumably occupies lattice position normally held by calcium, mostly in surfaces. (3) Fluoride, which is also deposited in the bone, occupies the hydroxyl positions, probably throughout the crystal. Therefore, while both fluoride and strontium are deposited and retained in bone, the mechanisms of deposition are separate and independent. (4) The fluoride content of the skeleton increases with ingestion of fluoridated water. (5) No calcium fluoride crystals can be found in bones or teeth regardless of the fluoride content of drinking water; the extra fluoride accumulates by exchange with hydroxyl forming a mixed fluorhydroxylapatite. (6) On the basis of solubility of calcium fluoride and strontium fluoride, and the ratio of calcium to strontium concentrations in blood, the precipitation of strontium-90 fluoride in living bone is a physiologic and thermodynamic impossibility. (7) In different areas, human diets contain widely varying amounts of strontium and of fluoride. Both are deposited in teeth, but the deposition of strontium bears no relation to the fluoride content of drinking water. (8) Two recent studies bearing specifically on the question of fluoride to strontium relations confirm the theoretical predictions that these elements deposit independently in the bone.

[EDITORIAL COMMENT: J. C. Muhler, G. K. Stookey, and M. J. Martin ("Effect of Sr^{89} on Fluoride Retention in the Rat," Proceedings of the Society for Experimental Biology and Medicine 102:644-7, 1959) found that the administration of radiostrontium-89 and fluoride together does not increase retention of either radiostrontium-89 activity or fluoride in the whole carcass or femur of the rat. Unpublished data (W. D. Armstrong and L. Singer) reveal that the $\frac{\text{radiocalcium-45}}{\text{radiostrontium-85}}$ deposition of these nuclides administered intraperitoneally to rats and deposited in bone or used for in vitro studies with powdered bovine bone is not altered by the fluoride concentration of the bone.]

62. Leone, N. C., Stevenson, C. A., Besse, B., Hawes, L. E., and Dawber, T. R. (National Institute of Dental Research): THE EFFECTS OF THE ABSORPTION OF FLUORIDE. II. A RADIOLOGICAL INVESTIGATION OF FIVE

HUNDRED AND FORTY-SIX HUMAN RESIDENTS OF AN AREA IN WHICH THE DRINKING WATER CONTAINED ONLY A MINUTE TRACE OF FLUORIDE. A. M. A. Archives of Industrial Health 21:326-7 (Apr.), 1960.

SUMMARY: X rays of residents of a city using fluoride-poor water showed a higher incidence of bone changes of various types than were found in a high-fluoride area. These findings support the hypothesis that disadvantageous effects on the bone structure may be associated with the prolonged use of drinking water containing an insufficient amount of fluoride.

Radiologic findings on 546 persons, 30 to 70 years old, who had resided for many years in Framingham, Mass., with a fluoride content of 0.04 ppm in drinking water, were compared with those obtained in investigations in Bartlett, Tex., having water with a fluoride content of 8 ppm, and Cameron, Tex., with 0.4 ppm fluoride. The radiologic protocol included: the design and instructions for the use of a specially devised plastic step wedge; exposure and development of the film by the same technician by the same procedure; identical views were taken in each instance.

Evaluations pertained to the anteroposterior view of the lumbar spine, sacrum, pelvis, trochanters, the proximal third of the femurs. Various lesions were noted in the tabulation of the results. Hypertrophic changes in the form of ligamentous calcification (bone spurs) were graded according to degree of severity. Since minimal to moderate hypertrophic changes, particularly in the form of ligamentous calcification or bone spurs are commonly found in adults over 40, only severe-localized 3+ and severe-generalized 4+ were regarded as significant.

When the master tabulation of interpretations of films and tabulations of results made independently by the respective radiologists was reviewed, the agreement between the independent readers was found to be remarkable, not only as to the respective findings, but also with regard to the degree of severity ascribed to the respective entities.

Among the diagnoses in the Framingham investigation were instances of "increased bone density," coarsened trabeculation, osteoporosis, ligamentous calcification (bone spurs), narrowed interspaces, compressed lumbar vertebrae, calcified nodes, vessels and intervertebral discs, Paget's disease of bone, tumors (bone and soft tissue), cholelithiasis and prostatic calcification. No cases of increased bone density combined with coarsened trabeculation were seen. Comparison of these data with those of the earlier Bartlett-Cameron investigation (Abstract No. 37) showed that the foregoing diagnoses occurred in relatively high frequency, and that these findings were not only commonly similar in number, but, in many instances, in excess of those described in the earlier report.

An unusual incidence of severe osteoporosis (77 out of 556) was found in Framingham; it may be significant that a considerable number of these occurred in the younger age groups, particularly in males. There was also an unusually high incidence of calcified nodes in the right side of the abdomen. Instances of "increased bone density" and coarsened trabeculation (when compared on the basis of prevalence per thousand of population) were significantly fewer than those found in Bartlett, Tex., but comparable to the rate in Cameron, Tex. When the prevalence rates of ligamentous calcification (bone spurs) were compared, a higher rate was shown to exist in Framingham.

The small number of cases of increased bone density and of coarsened trabeculation, plus the unusually large number of cases of osteoporosis in Framingham, supports the hypothesis that disadvantageous effects on the bone structure of the adult population may be associated with the prolonged use of drinking water that contains an insufficient concentration of fluoride.

63. Smith, F. A., Gardner, D. E., Leone, N. C., and Hodge, H. C. (University of Rochester, N. Y., and National Institute of Dental Research): THE EFFECTS OF THE ABSORPTION OF FLUORIDE. V. THE CHEMICAL DETERMINATION OF FLUORIDE IN HUMAN SOFT TISSUES FOLLOWING PROLONGED INGESTION OF FLUORIDE AT VARIOUS LEVELS. A. M. A. Archives of Industrial Health 21:330-2 (Apr.), 1960.

SUMMARY: The ingestion of water containing fluoride up to 4 ppm does not cause an accumulation of fluoride in soft tissue. The higher concentrations of fluoride in the aorta are not correlated with waterborne fluoride; they increase with age and may be associated with increasing calcification in the aorta with advancing age.

The fluoride content of soft tissue obtained at autopsy from residents of cities, with a fluoride content of the water supply varying from 0 to 4 ppm, as determined under the protocol described by Leone, et al. (1960), was as follows in ppm in desiccated tissues:

Ppm fluoride in water	Heart	Liver	Lung	Kidney	Spleen	Aorta
0: 4 male, 1 female, age 32-65	1.39- 2.49	1.45- 3.26	1.79- 4.21	2.50- 2.90	1.83- 4.24	2.64- 106.1
0.5: 1 male, 1 female, age 32-40	1.22- 4.29	0.92- --	-- --	1.35- 4.19	2.17- 7.31	2.65- 10.00
1.0: 2 male, 2 female, age 64-85	1.95- 2.53	1.05- 3.79	2.68- 10.5	3.78- 4.95	1.90- 16.7	20.68 166.3
	23.3 (heart + aorta)					
2.6: 5 female, age 47-83	1.19- 3.18	1.24- 2.84	4.04- 12.4	2.74- 9.02	2.63- 5.66	5.29- 40.63
3.7: 4 male, age 36-50	1.71- 3.60	1.01- 2.92	3.31- 4.07	2.28- 7.37	1.34- 4.51	3.09- 6.04
4.0: 3 male, age 26-71	2.65- 6.81	1.96- 5.41	4.46- 11.17	7.63- 25.6	-- --	6.21- 59.4

These results show that the ingestion of fluoride in water to 4 ppm does not result in the accumulation of fluoride in soft tissues. The aorta contains more fluoride than do any of the other tissues, and the fluoride content correlates with age but not with ingested fluoride. It is suggested that the increase of fluoride in aorta with age may be associated with an increase of calcification in this tissue with advanced age.

64. Zipkin, I., McClure, F. J., and Lee, W. A. (National Institute of Dental Research):

RELATION OF THE FLUORIDE CONTENT OF HUMAN BONE TO ITS CHEMICAL COMPOSITION. Archives of Oral Biology 2:190-5 (Aug.), 1960.

SUMMARY: The consumption of water containing fluoride in concentrations up to 4 ppm did not alter the calcium or phosphorus content of bone. There were variable increases or decreases in the concentrations of magnesium, potassium, carbon dioxide, and citrate, indicating that fluoride replaces some ions located at the surface of the bone crystal.

Sixty-nine samples of bone (iliac crest, rib and vertebra) removed at autopsy from 23 persons, 26 to 90 years of age (see Abstract No. 50) who had consumed drinking water containing fluoride in concentrations of less than 1, 1, 2.6, or 4 ppm for 10 to 87 years, were analyzed for calcium, phosphorus, magnesium, sodium, potassium, carbon dioxide, and citrate. The percentage of calcium and phosphorus in the dry, fat-free bones was normal although they contained as much as 0.4% (4,000 ppm) fluoride. Even though there had been a tenfold increase in the fluoride content of bone of persons who had lived in the 4-ppm areas, no relation was apparent between the fluoride present in bone ash and the calcium or phosphorus content. The calcium to phosphorus ratio remained unchanged. There was a variable slight increase in the ash content of the individual bones, i.e., from 53.51 to 58.62% in the iliac crest, 56.04 to 57.38% in the rib, and 49.82 to 52.33% in the vertebra, as the fluoride in water increased. With increased levels of fluoride in the ash (0.08 to 0.8%) there was a slight increase in magnesium and a decrease in carbon dioxide. The citrate content decreased markedly with increased fluoride. A slight decrease in sodium and little or no change in potassium were noted.

The reduction in citrate with a concomitant increase in fluoride suggests that citrate, which is assigned to positions on the crystal surface, may be replaced by fluoride through ion-exchange processes. Due to cessation of bone growth, exchange reactions would predominate in mature and aged bones; thus advanced age at the time of initial exposure to fluoride would favor the deposition of most of the fluoride at the expense of surface-limited ions.

65. Largent, E. J.: SKELETAL FLUOROSIS IN MAN. Chapter 2 in: Fluorosis. The Health Aspects of Fluorine Compounds. Columbus, Ohio State University Press, 1961, pp. 8-21.

SUMMARY: Skeletal fluorosis occurred in Danish workmen who had absorbed for many years exceedingly large amounts of fluoride: more than 25 milligrams and up to 70 milligrams per day. Bone changes in endemic high-fluoride regions of India, Africa, and other countries, have also been reported. The exact amount ingested is not known, but presumed to be higher than reported.

For proper diagnosis, the following is required: proved absorption of fluoride of 10 to 15 milligrams daily, or urinary concentrations averaging more than 8 ppm over a period of more than 5 years.

The critical analysis of numerous cases of skeletal fluorosis reported in the literature starts with the investigations conducted by Roholm in 1931-1932 of workers at the Øresund Chemical Works in Copenhagen, engaged in processing the fluoride-containing ore, cryolite. In most of the operations the material was ground, conveyed, and handled in the dry state; the dust generated was so extensive that it penetrated all of the workrooms in significant amounts (dust content in workrooms ranged from 22 to 48 milligrams (mg.) per cubic meter of air, with a fluoride content ranging from 11.5 to 25.2 mg. per cubic meter. The dust content of 2 samples of air in the space around the enclosed machine-separator was 815 and 994 mg. per cubic meter, with a fluoride content of 427 and 521 mg. per cubic meter).

The health status of each worker during the entire period of employment was described by indicating the number and type of complaints. Gastric complaints were most frequent, probably because of the daily intake of large amounts of cryolite dust (e.g., excess of 25 mg. of fluoride ion; according to Roholm, between 0.2 and 1 mg. per kilogram of body weight daily) in swallowing dust trapped in the upper respiratory passages and inhaling the dust. The fact that 57 of the 68 employees had shown evidence of increased radiopacity of bone, 4 of whom had lost most of the motility of the spinal column, suggests that the total amount of fluoride absorbed each day was very large. Other than the gastric complaints and abnormal skeletal radiologic findings, nearly all other findings were within normal limits for Copenhagen workmen. The radiologic changes of osteosclerosis were classified into 3 phases of severity. These related generally to the length of employment and therefore to exposure.

Largent points out that the inclusion of data concerning the incidence of diseases of the bones and joints such as rheumatoid arthritis, ankylosis of the lumbar vertebrae, syphilitic lesions, Paget's disease, and osteopetrosis in several hundred men performing hard labor in Copenhagen during the years of the investigation would have been particularly valuable to permit the establishment of a causal relationship between osseous deposition of fluoride and progressive increases in radiopacity of human bones. The presence of very extensive ankylosing spondylitis in one workman with 12 years of exposure to cryolite, compared with the absence of radiographically discernible bone changes in one after 24 years of exposure, gives rise to some uncertainty as to the extent to which fluoride ion may have been the principal etiologic agent.

The publication of Roholm's investigations was followed by a series of reports of alleged fluorosis in other parts of the world, such as in North and South Africa, Argentina, China, India, in the United States, and others. In some of these reports, the nature and extent of the exposure is poorly established; in others, where the data on fluoride ingestion, osseous deposition, and urinary excretion of fluoride may be satisfactory, the skeletal changes described are either radiologically slight or completely nondisabling; in still others, the disease entities may have been incorrectly diagnosed as fluorosis. Brailsford (in "The Radiology of Bones and Joints," 1953) and Chamberlain (in Proceedings of the California Academy of Medicine, 1937-38) have pointed out that some of Roholm's cases presented an appearance indistinguishable from Paget's disease or metastatic carcinoma and that some of the changes are caused by the trauma of strenuous hard labor, entirely unrelated to fluoride exposure.

The cases described in India (Shortt, et al., Indian Journal of Medical Research 25:553, 1937, and others) are discussed in connection with the concentrations of fluoride that were probably actually ingested rather than those reported in the articles. It is pointed out that because of the nature of the wells or water holes described, it seems likely that cloudy or even muddy water was dipped out for drinking and that suspended matter containing fluoride would have been ingested; in other words, that the actual concentrations of fluoride ingested were therefore higher than were present in the clear waters analyzed. This was evident in one reported case of a person who continued to excrete high concentrations of fluoride in his urine after a month of low fluoride intake at the hospital.

That the poor nutritional status of persons in India afflicted with severe osteosclerosis is connected with the development of the changes was seen in the reported observation that among the more affluent persons living in the same areas, skeletal abnormalities were either much less severe or not detectable. A social factor in that the poorer classes in India have often been denied the use of wells or water holes reserved to upper castes may have resulted in a dissimilar intake of fluoride among different residents of the same village. In comparison, the findings in Texas and Oklahoma and other investigations in the U. S. are reviewed (Leone, et al., Abstract No. 35; Stevenson and Watson, Abstract No. 47; McCauley and McClure, Abstract No. 36) where in spite of relatively high fluoride ingestion from waters (8 ppm and more), such bone changes were not observed.

In summary, fluoride-induced bone changes clearly demonstrated in man include increased radiopacity, and hyperostoses in the forearm and leg, principally in the interosseous membranes. The diagnosis ordinarily cannot be established by clinical radiography alone when only slight or borderline changes are observed in the person who has had but a few years' exposure to fluoride. Confirmatory evidence, such as histologic examination and chemical analysis of bone obtained by biopsy or at autopsy, is needed. Required corroborative evidence in any case is: (a) proved absorption of fluoride of 10 to 15 mg. per day, or (b) urinary concentrations averaging more than 8 ppm over a period of more than 5 years.

66. Largent, E. J.: INGESTION, INHALATION, EXCRETION, AND STORAGE OF FLUORIDE BY MAN. Chapter 3 in: Fluorosis. The Health Aspects of Fluorine Compounds. Columbus, Ohio State University Press, 1961, pp. 22-56.

SUMMARY: The average daily fluoride intake and elimination by a human subject from the diet (fluoride in water, 0.2 ppm) was nearly uniform, 0.4 to 0.5 milligram. When extradietary fluoride was ingested in various dosages, a certain amount of it was eliminated and a proportion deposited in the bones. Evidence was obtained that there is a certain related amount of fluoride deposited in bones for each level of fluoride ingestion. So long as the level of intake continues unchanged, any further storage will be offset by the mobilization of some of the previously stored fluoride, so that a balance between absorption and storage, and mobilization of some of the previously stored fluoride and excretion is maintained.

This chapter is an account of the extensive investigations by the author and comparison with results obtained by others on the metabolism of fluoride.

The fluoride balance between intake and output was studied in a human experimental subject in Cincinnati (0.2 ppm in water), who, for 20 weeks collected duplicates of all food and beverages consumed; through that time, the average intake and output of fluoride were nearly uniform: 0.4 to 0.5 milligram (mg.) per day.

The subject then ingested in diet 6 mg. of fluoride per day for various periods up to 14 weeks in the form of sodium fluoride solution, calcium fluoride as solution and dry salt, bone meal, and sodium fluoborate. All but 2 to 4% of the fluoride in solution was absorbed and about 50% stored in the tissues, almost 50% having been recovered in the urine. Dry calcium fluoride and bone meal were only partially absorbed, about 70 and 37%, respectively; all of the fluoborate was absorbed and totally excreted in the urine. Similar results were obtained when fluoride was ingested at levels of 12, 18, 19, 25, and 36 mg. per day. When finely powdered fluoroapatite (rock phosphate) was ingested within one day in a total amount of almost 16 mg., to simulate industrial exposure, 19% was recovered in the feces by the next day, showing that 81% was absorbed.

In other studies, a subject ingested 3 mg. fluoride a day (as sodium fluoride) in addition to the dietary fluoride for 25 weeks, then increased it to 12 mg. per day for 130 weeks. The subject was given periodic clinical and radiologic examinations throughout the period. No abnormalities, signs or symptoms occurred; X rays were normal. Still another subject ingested extradietary fluoride at 3 mg. daily for 45 weeks. These studies showed that there was an initial increase in the excretion of fluoride, somewhat more fluoride being recovered in the urine during cool than in hot weather, indicating that some fluoride was excreted in the perspiration; also, that the rate of deposition in tissues gradually decreased with duration of exposure. This was clearly seen in the subject ingesting 3 mg. of fluoride (as sodium fluoride) per day for 45 weeks. Excretion of fluoride rose rapidly as soon as the extradietary intake was started; of the average amount absorbed, 66% was recovered in the urine and the balance deposited in the body. In the final 5 weeks, the average amount of fluoride recovered in the urine was 82% of that absorbed, showing a gradual decrease in the rate of storage. This means that a point of saturation in bone resulted from a given amount of ingestion. By use of an equation it was predicted that with ingestion of 3 mg. daily continuously, about 98% saturation of skeletal tissue would occur in 170 weeks; i. e., intake and output of fluoride reaches a balance in about 1-1/2 to 3 years after the start of ingestion at this concentration. If fluoride intake is then increased, storage is increased abruptly, then diminishes slowly, and a new equilibrium of bone saturation is reached; if fluoride intake is reduced, excretion of fluoride exceeds the intake. This picture of the fluoride balance was further seen in 10 volunteers residing in 5 cities where the drinking water contains various fluoride levels (from 2 to 20 ppm), duplicates of whose diet and excreta were shipped to Cincinnati and analyzed. The observations are described further below.

The metabolism of inhaled fluoride was studied also in 5 human subjects exposed to 3 ppm of hydrogen fluoride. This concentration caused some very slight discomfort (stinging sensation) of the skin and eyes during exposure. Careful medical examination before and after the experiments showed no other effects. The results revealed that the fluoride was rapidly absorbed and promptly eliminated in the urine and in greater than expected amounts in the feces.

The renal elimination of fluoride in relation to ingestion is discussed on the basis of the above experiments. In general, the extent of the increase in the concentration of fluoride in the urine was related to the amounts absorbed, and the fluorides having the greatest aqueous solubility were absorbed almost completely, with increases in urinary fluoride levels related directly to and proportional to the levels of fluoride intake. The urinary excretion of people who ingested fluoride-containing drinking water in cities investigated by McClure and Kinser, is discussed. Largent also found with 8 of 10 of the volunteers from cities with water containing from 2 to 8 ppm fluoride that they were eliminating all or nearly all of the fluoride they were ingesting; in 7 of these, urinary fluoride was nearly identical with the average concentration of fluoride present in the water, in fact exceeded it in some cases. The 2 volunteers from O'Donnell, Tex. (fluoride in water, 20 ppm), differed in this respect probably because they frequently drank carbonated beverages bought in nearby cities with comparatively low fluoride in the drinking water, so that their fluid intake was diluted to the extent that neither the fluid intake nor the urinary fluoride bore any relation to the fluoride content of the local water. The amounts of fluoride ingested each day in the foods and liquids consumed daily by 7 of the volunteers were greater than the amounts of fluoride per liter of drinking water of their city, which may have been due to the contribution of the fluoride in the water to solid foods cooked in it. This suggests the need of complete balance studies in order to estimate accurately the intake of fluoride in a city with unusually high concentrations of fluoride in the water.

Concentrations of fluoride in blood based on statistical analysis, as reported by F. A. Smith, D. E. Gardner, M. J. Voss, D. Wing, P. Dunn, J. Figueras, and J. W. Keating ("Investigations on the Metabolism of Fluoride. I. The Determination of Fluoride in Blood," Journal of Dental Research 30:182-8, 1951) are very low. Largent's analyses of the blood of a subject just before, during, and immediately after inhalation of hydrogen fluoride showed variable and inconsistent results. Caution is expressed that with presently available methods, truly dependable data can be obtained only through statistical evaluation of large groups of blood analyses.

The fluoride not recovered during observations on the fluoride balance was assumed to have been deposited in the bones. Even by considering that some additional amounts may have been excreted in the sweat of the subjects (these analyses were not done in all cases), there is a certain related amount of fluoride deposited in bones for each level of fluoride ingestion. So long as the level of fluoride ingestion continues unchanged, any further storage will be offset by the mobilization of some of the previously stored fluoride so that a balance between absorption and storage, and mobilization of some of the previously stored fluoride and excretion is maintained. This was seen in the 10 volunteers from 5 cities with varying fluoride content of water; the intake and output of fluoride were very nearly equal, meaning that a state of equilibrium had been reached. Mobilization and excretion of stored fluoride was shown by the experimental subjects who had earlier ingested added fluoride at 3 and 12 mg. per day and of a subject who had for 19 years lived in Amarillo, Tex. (4 ppm fluoride in drinking water), before coming to Cincinnati (0.2 ppm fluoride in water). The sharply decreased intake of fluoride resulted in the elimination of fluoride in the urine greatly in excess of the intake over an extended period of time.

In an attempt to relate excretion of fluoride to kidney disease, Largent administered 6 mg. fluoride daily to 2 hospitalized volunteers with subnormal kidney function. Indications were that greater amounts of fluoride were stored in the bone. As the duration of these experiments was brief, the desirability of collecting additional balance data of this type is expressed. To date there has been no evidence, however, that kidney disease has been induced by fluoride in drinking water even at such high levels as 8 to 26 ppm.

[ABSTRACTOR'S NOTE: The articles reporting these experiments separately were published as follows: (1) W. Machle, E. W. Scott and E. J. Largent: "The Absorption

and Excretion of Fluorides. Part I. The Normal Fluoride Balance," Journal of Industrial Hygiene and Toxicology 24: 199-204, 1942; (2) W. Machle and E. J. Largent: "The Absorption and Excretion of Fluoride. II. The Metabolism at High Levels of Intake," Journal of Industrial Hygiene and Toxicology 25:112-23, 1943; (3) E. J. Largent and F. F. Heyroth: "The Absorption and Excretion of Fluorides. III. Further Observations on Metabolism of Fluorides at High Levels of Intake," Journal of Industrial Hygiene and Toxicology 31:134-8, 1949; (4) E. J. Largent: "Rates of Elimination of Fluoride Stored in the Tissues of Man," A. M. A. Archives of Industrial Hygiene and Occupational Medicine 6:37-42, 1952.]

67. Ericsson, Y., and Malmnäs, C. (Royal Dental School, Stockholm, Sweden): PLACENTAL TRANSFER OF FLUORINE INVESTIGATED WITH F^{18} IN MAN AND RABBIT. Acta Obstetricia et Gynecologica Scandinavica 41:144-58, 1962.

SUMMARY: Fluoride does not accumulate in placenta, pituitary, thyroid or mammary glands. Even sudden increases of fluoride in the maternal blood cannot produce high levels in fetal blood.

Most of the previous investigations of the transfer of fluoride across the placenta have been done on animals fed relatively high concentrations of fluoride. In man, only few and incomplete investigations have been performed, the results of which have been variable. In discussing these earlier investigations, the author points to possibilities of error, especially in the older figures, in the chemical analysis of low concentrations of fluoride in blood and organs. Radioactive fluoride was used by the author in his own investigations. A dose of 5 microcuries of radiofluoride was administered intravenously to four women, 18 to 39 years old, in all of whom therapeutic abortion was to be combined with sterilization. Blood was taken from the mother's arm and from the umbilical cord and/or the heart of the fetus. Radiofluoride was evidently rapidly eliminated from the maternal blood. During observation periods up to 10 minutes after injection, the radiofluoride content of the fetal blood varied between 1/4 and 1/10 of that of the maternal blood while in the placenta it ranged between the maternal and fetal blood. No rapid accumulation was thus found in the placenta at these stages of development (12, 15 and 26 cm. fetal length).

Because the number of available patients was limited, and in order to extend analyses to a variety of organs, additional experiments were done with rabbits. Three rabbits which had only 2 days left before expected parturition were injected intravenously with 8 to 10 microcuries of radiofluoride per kilogram of body weight. Maternal blood was collected from a carotid artery before, and at 2- to 5-minute intervals after radiofluoride injection.

The fetuses were removed successively over a 35-minute period after injection. The radiofluoride transfer to the fetal blood was very small, increasing only slightly during the 35-minute period. In no case did the radiofluoride concentration in the fetal blood reach 1/3 of the simultaneous radiofluoride concentration in the maternal blood. The radiofluoride activity of the thyroid and hypophysis of the mothers was of the same order as that of the blood while in the mammary glands in the two cases tested it was considerably lower.

It is concluded that on the basis of these data, even sudden increases of the fluoride concentration of the maternal blood cannot produce any great rises in the concentrations of fetal blood. In contrast to observations reported by some authors, there was no fluoride accumulation in placenta, pituitary, thyroid or mammary glands of these rabbits.

68. Heasman, M. A., and Martin, A. E. (Ministry of Health, London): MORTALITY IN AREAS CONTAINING NATURAL FLUORIDE IN THEIR WATER SUPPLIES. Monthly Bulletin of the Ministry of Health and Public Health Laboratory Service 21:150-60 (Aug.), 1962.

SUMMARY: The overall mortality in the fluoride and control areas of England and Wales is the same.

The study comparing mortality in natural fluoride areas with areas deficient in fluoride in England and Wales was done in a manner similar to the investigation reported by Hagan and associates (Abstract No. 57), but with an extended list of diseases.

Death statistics for the period 1950-59 were used. These were adjusted for age and sex differences in the population of each area by a method of indirect standardization using the age/sex specific rates for England and Wales in 1950-52 as the standard, and applying these to the 1951 census populations for the different areas; then intercensal changes in population were allowed for by multiplying the expected deaths calculated by the ratio of the 1955 population to the 1951 populations. Standardized mortality ratios (S. M. R.) were obtained by expressing the actual number of deaths as a percentage of the expected number.

Eighteen areas with water supplies containing average fluoride concentrations from 0.4 to 5.8 ppm, serving a total population of 428,960, were compared with their matched controls with a total population of 368,580 provided with water containing fluoride in amounts less than 0.2 ppm. Of the fluoride areas, 15 with the higher concentrations, and mostly small communities in predominantly rural areas, are in the south of England and 13 of them are located in East Anglia. On the other hand, the 3 northern towns (2 of them sharing a common water supply), that are large and highly industrialized, have a combined population only 34,000 less than the combined population of the southern towns.

The most important difficulties in investigating the effect of a particular agent on mortality are the crude nature of mortality data, and the selection of areas for comparison. As there are many unknown factors contributing to a person's death and no allowance can be made for internal migration in the population, vital statistics constitute only a very crude tool. Also, ideally, control areas should be selected so as to differ in only fluoride content, but be similar to their partner geographically, socially and economically; this proved to be an impossible task.

In addition to comparing all causes of death together, the following were included: tuberculosis; all cancer, with cancer of stomach, lung, and leukemia evaluated separately; vascular lesions of the central nervous system; angina, and other heart diseases; influenza, pneumonia; bronchitis; peptic ulcer; nephritis and nephrosis; congenital malformations; all other diseases; accidents, poisonings and violence.

Some significant differences were observed when individual causes of death were compared; however, on the basis of differences in geographic, social, economic and other factors, where the higher incidence fell into the fluoride group, a relationship with fluoride was hard to conceive, for the figures were below the national or regional averages.

The higher mortality from cancer of the stomach in the 2 fluoride groups taken as a total was given close attention: however, there was no association between fluoride and stomach cancer mortality in the southern areas; also, in the 2 northern towns sharing a common water supply, the S.M. R. for stomach cancer was 117 in one and 200 in the other; other areas, some highly industrialized, but with little or no fluoride, have higher death rates for stomach cancer; in addition, factors unrelated to fluoride, such as social class and geographical area play a part in the etiology of stomach cancer. Of further pertinence is the finding of P. Stocks in 1958, that no increase in cancer of the stomach in heavy tea drinkers could be found when compared with moderate consumers of tea. Had fluoride been the cause, heavy tea drinkers would have been expected to be unduly susceptible to this disease.

Therefore, where significant differences did exist, it was considered very unlikely that fluoride was the cause. The most notable finding was that in spite of the difficulties discussed above, the overall mortality was the same in the fluoride and control areas.

B. EVALUATION OF THE LITERATURE; REPORTS OF COMMITTEES; ENDORSEMENT OF FLUORIDATION OF DRINKING WATER

69. Dean, H. T. (National Institute of Dental Research): U. S. P. H. S. POSITION ON FLUORIDATION OF PUBLIC WATER SUPPLIES. Journal of the American Water Works Association 43:672-4 (Sept.), 1951.

The American Water Works Association submitted to the U. S. Public Health Service (USPHS) 5 questions most frequently asked about fluoridation in order to obtain authoritative answers.

The question upon what evidence the USPHS based its conclusions that the adjustment of the fluoride concentration of a public water supply to about 1 ppm would not be harmful to the consumer is answered that (1) upon critical analyses of the results of a large number of epidemiological and experimental laboratory investigations, 1 ppm is well below the level of toxicity.. (2) For generations, large population groups have used water containing about 1 ppm with no evidence of ill effects. (3) Fluoride is contained in trace quantity in body organs and tissue; average daily diet contains 0.2 to 0.3 milligram of fluoride. (4) Reports of toxic effects should be critically and dispassionately analyzed as to whether they were the result of an excessive intake of fluoride and whether the results have been supported by scientifically acceptable experimental or clinical evidence. Such reports of toxic effects of fluoride as appear from time to time, upon critical analysis were found to bear no relevance to the proposal of adding 1 ppm to public water supply.

The question of whether it is correct to designate fluoridation as a mass medication is answered that fluoridation is not recommended for treatment or cure, but for prevention. Fluoridation simulates a purely natural phenomenon.

The question, what comparative epidemiologic studies show in the incidence of cancer in cities in which the public water supply is relatively free of fluoride and in those containing about 1 ppm fluoride, is answered that such studies show nothing (based on San Francisco (substantially fluoride-free) and Denver (1 ppm) surveys by the National Cancer Institute in 1937-1939) which would suggest that prevalence of malignancy is affected by fluoride-containing water.

The question, what the present USPHS policy is toward fluoridation of water supplies in cities in which the supply naturally contains less than the optimal amount of fluoride necessary to control dental decay adequately, is answered that an increase to the optimal level of 1 ppm is recommended. On April 24, 1951, Surgeon General Scheele in testimony presented to the Senate subcommittee on appropriations stated: "During the past years, our studies progressed to the point where we could announce an unqualified endorsement of the fluoridation of public water supplies as a mass procedure for reducing tooth decay by two-thirds."

The question, what the USPHS policy is in relation to towns where the public water supply naturally contains more than 1.5 ppm fluoride is answered that the removal or dilution of excessive fluoride wherever possible is recommended in order to prevent development of mottled enamel.

70. American Medical Association: STATEMENT BEFORE HOUSE COMMITTEE BY DR. GEORGE F. LULL, SECRETARY AND GENERAL MANAGER OF THE A. M. A., ON FLUORIDATION OF DRINKING WATER. Journal of the American Medical Association 148:1130 (Mar. 29), 1952.

Subsequent to a study of all the available data on the ingestion of fluorides in drinking water, the Councils on Pharmacy and Chemistry and Foods and Nutrition adopted a statement as to the safety of fluoridation on Nov. 2, 1951.

This statement as published in the Journal of the American Medical Association 147:1359, 1951, is as follows: "The Council on Pharmacy and Chemistry and the Council on Foods and Nutrition have been requested to state their opinion regarding the safety of fluoridation of water supplies, a procedure which has now been adopted by more than 140 cities. The Councils are unaware of any evidence that fluoridation of community water supplies up to a concentration of 1 ppm would lead to structural changes in the bones or to an increase in the incidence of fractures. The only difficulty so far revealed is a possible increase in mottling of the tooth enamel. The available evidence based on thousands of observations indicates that the incidence of mottling of the enamel in children who drink water containing fluoride up to a concentration of 1 ppm is minimal and detectable only by careful dental examination. It occurs only in a small percentage of children and is so slight as not to present a problem from the point of view of appearance or strength of the teeth. Evidence of toxicity other than the effect on enamel has not been reported in communities where the water supply has several times this concentration. After considering the evidence available at this time, the Councils believe that the use of drinking water containing up to 1 ppm of fluoride is safe. However the use of products which are naturally high in fluoride content, such as bone meal tablets, or of lozenges, dentifrices, or chewing gum, to which fluoride has been added, should be avoided where the drinking water has been fluoridated. In places where children are subjected to warm temperatures and consequently drink large amounts of water, a lower concentration of fluoride may be necessary to avoid mottling of the teeth."

The House of Delegates of the American Medical Association at its meeting, Dec. 4 to 7, 1951, adopted a resolution endorsing the principle of fluoridation of community water supplies.

[ABSTRACTOR'S NOTE: At the 11th Clinical Meeting, Dec. 3-6, 1957 (Journal of the American Medical Association 165:2090-2, 1957), the House of Delegates voted to take a policy stand that "fluoridation of public water supplies is a safe and practical method for reducing the incidence of caries during childhood." House action came in response to a 27-page joint report of the Council on Drugs and the Council on Foods and Nutrition which concluded that "fluoridation of public water supplies should be regarded as a prophylactic measure for reducing tooth decay at the community level and is applicable where the water supply contains less than the equivalent of 1 ppm."

In April, 1961, this position was confirmed by the Executive Vice President (Journal of the American Dental Association 62:741-2, 1962).

Also, in a Letter to the Editor of the New York Times, Aug. 13, 1962, Richard P. Bergen, Staff Attorney of the A. M. A. stated that the position of the A. M. A. on the subject is contained in a 24-page booklet, "Statement of Fluoridation of Public Water Supplies by the House of Delegates of the American Medical Association," copies of which may be obtained from the A. M. A. The letter was published in order to discourage any misrepresentation of the position of the A. M. A. on this vitally important subject.]

71. Heyroth, F. F. (University of Cincinnati, O.): TOXICOLOGICAL EVIDENCE FOR THE SAFETY OF THE FLUORIDATION OF PUBLIC WATER SUPPLIES. American Journal of Public Health 42:1568-75 (Dec.), 1952.

This critical discussion of the present state of knowledge of the toxicology of the fluoride ion brings out the following points:

Acute toxicity: The study of acute poisoning in experimental animals has pertinence only in so far as it may reveal which organs are most vulnerable to the action of fluoride. The lethal dose for rabbits was reported to be from 50 to 200 milligrams (mg.) per kilogram of body weight. In human self-experimentation, 250 mg. of sodium fluoride was taken at one time without harm.

Chronic toxicity: The syndrome involving bone changes was first described as occurring in animals grazing on vegetation contaminated by dusts derived from phosphate deposits or volcanic ash. In laboratory animals, the continued ingestion of diets containing 7 to 12 ppm fluoride caused dental fluorosis detectable only with a lens, and levels from 100 to 230 ppm inhibited growth. From the results of animal experimentation it is concluded that interference with growth and other changes cannot be induced by a daily intake too small to give rise to dental abnormalities. Estimates of the maximum daily intake that may be tolerated by animals show variations in susceptibility, which would make hazardous any attempt to predict the maximum safe human intake, were there no observations upon the condition as it occurs in man.

Bone changes from industrial exposure have occurred in workmen who had inhaled excessive amounts of fluoride-containing dusts over a long period of time, and as a result had deposited large quantities of fluoride in their bones (estimated as about 12 mg. per day, after daily inhalation of about 0.2 to 0.35 mg. fluoride per kilogram of body weight). No other histopathologic changes were found. Human experimentation has yielded valuable information on the metabolism of fluoride, the most important finding of which is that when daily intake did not exceed 4 to 5 mg. of fluoride, the major portion was eliminated from the body.

After reviewing cases of human fluorosis (bone changes) from waterborne fluoride, it is concluded "that the prolonged intake of quantities of fluoride too small to induce dental fluorosis does not give rise to any of the non-dental manifestations of chronic intoxication by fluorides. Epidemiological data and clinical and radiographic examinations of exposed industrial workers indicate that only when the fluoride content of a water supply exceeds 5 or 6 ppm will its prolonged usage give rise to detectable osseous changes and then only in the most susceptible persons. The evidence as a whole is consistent in offering assurance that bringing the fluoride concentration in communal water supplies to that known to be optimal for dental health is a prophylactic public health procedure which has an ample margin for safety."

72. National Research Council: REPORT OF THE AD HOC COMMITTEE ON FLUORIDATION OF WATER SUPPLIES. K. F. Maxcy, Chairman, J. L. T. Appleton, B. G. Bibby, H. T. Dean, A. McG. Harvey, F. F. Heyroth, A. L. Johnson, H. A. Whittaker, and A. Wolman. Publication No. 214, 8 pp., 1952; Journal of the American Water Works Association 44:1-9 (Jan.). 1952.

The summary and conclusions of the report are as follows: "Under normal conditions of living, fluorine is a trace element in human nutrition. A variable and important source is drinking water. Many of the public water supplies in the U. S. are deficient in this element. Children dependent upon such supplies have a high dental caries attack rate as compared with children living in cities having water supplies containing about 1 ppm of fluoride. The advantage of the latter group is considerable and is of the order of one-third to one-half as much caries. The caries-preventive effect of adequate fluoride intake is principally conferred upon children up to about the 12th year of life, during the period when dentin and enamel of the permanent dentition are being formed. This increased resistance to dental caries is carried over into later life to an appreciable degree.

"The results of experimental studies conducted in the laboratory give consistent support to the concept of the inhibitory effect of fluoride on the caries process. There is a safe margin between trace quantities in drinking water which are required for optimal dental health and the amount which produces undesirable physiological effects. The most sensitive indication of the latter is interference with normal calcification of the teeth, which is manifested in mottled enamel, or endemic fluorosis. This effect, although compatible with caries-resistant tooth structure and, within certain limits, apparently with physiological well-being, is esthetically undesirable. The level of fluoride concentration in drinking water which is associated with the appearance of mottled enamel varies with individual susceptibility and with the amount of water consumed. The upper level of safety has been reached in the northern part of the U. S. in domestic water supplies containing approximately 1 to 1.5 ppm fluorine, in the southern part of the country approximately 0.7 ppm.

"There is no reason to believe that prolonged ingestion of drinking water with a mean concentration below the level causing mottled enamel will have an adverse physiological effect. Progress reports in several communities in which sodium fluoride has been added to the water supplies of low fluoride content indicate that this procedure will reduce the caries attack rate in children. There is evidence to suggest that it will confer an appreciable measure of protection to teeth of adults.

"In view of these considerations, the Committee recommends that any community which includes a child population of sufficient size, and which obtains its water supply from sources which are free from or are extremely low in fluorides, should consider the practicability and economic feasibility of adjusting the concentration to optimal levels. This adjustment should be in accord with climatic factors and a constant chemical control should be maintained. With proper safeguards, this procedure appears to be harmless. However, it should be conducted under expert dental and engineering supervision by the state board of health. It should not be undertaken unless this can be provided.

"How much reduction in the prevalence of caries will actually be realized in a particular community will vary according to local conditions. The procedure will supplement but not supplant other dental health measures. About one-half of the population of this country is living in small villages and rural areas and will not benefit by fluoridation of public water supplies. Other provisions for preventing dental caries in this fraction of the population should be continued and developed."

73. Anonymous: RESOLUTIONS OF WATER FLUORIDATION. Water Works Information Exchange Canadian Section, American Water Works Association 8, No. 1, Sec. A:1-3; No. 2, Sec. A:4, 1953.

The resolutions adopted by the Canadian Public Health Association (June 1952), by the Canadian Dental Association and the Canadian Medical Association (Jan. 27, 1953), by the Public Health Committee of the Ontario Dental Association (Feb. 2, 1953), and a further resolution by the Canadian Dental Association (Oct. 17, 1953) respecting approval of fluoridation are presented.

74. Great Britain Ministry of Health, Department of Health for Scotland, Ministry of Housing and Local Government: THE FLUORIDATION OF DOMESTIC WATER SUPPLIES IN NORTH AMERICA AS A MEANS OF CONTROLLING DENTAL CARIES. Report of the United Kingdom Mission, February-April 1952, by J. R. Forrest, J. Longwell, H. H. Stones, and A. M. Thomson.

London, Her Majesty's Stationery Office, 1953, 101 pp.

The report covers the following subjects: historical background; dental effects of fluoridated water supplies; possible hazards; fluorine compounds and methods of usage; fluoridation of water supplies; the public reaction in America. Conclusions are that epidemiological studies in U. S. have demonstrated beyond doubt that among children and adults, who have been born and brought up in areas where the drinking water contains fluoride at a level of 1 ppm or more, there is much less dental caries than in areas where the water is free from fluoride. In certain communities where fluoride has been added to formerly low-fluoride water supplies, the dental effects of fluoridation have been studied carefully, and conclusive evidence has been obtained that the reduction in the incidence of caries is at a level comparable with that experienced where fluoride occurs naturally in the water.

There is nothing to suggest that a water containing fluoride, naturally derived, has properties different from those of a water to which fluoride has been added. At levels recommended, there is no risk of mottled enamel. No scientific evidence has been found of any danger to health from the continued consumption of water containing fluoride in low concentration.

The opinion regarding the many suggestions made that certain ill effects may occur is "we can only comment that the proving of a negative is extremely difficult. Meanwhile, we are impressed by the fact that millions of people are living in ordinary good health on waters containing fluorides at levels of 1 ppm or more." The opinion is also that fluoridation of water supplies is preferable to all other methods of fluoride supplementation.

Recommendations are that fluoride be added to the water supplies of some selected communities which will be regarded as study centers. Before this is done, base-line information on the incidence of dental caries in children and adults in these and control communities must be obtained; the required dose of fluoride must be assessed; it should be determined that adequate supplies of fluoride in the most suitable form are available; machinery necessary for the addition of fluoride must be developed. Research into the effects on health and disease of the continued use of waters containing low levels of fluoride should be encouraged. Simple methods for the addition of fluoride to privately owned supplies serving small communities should be investigated.

Fifteen appendixes, including the full report by F. F. Heyroth to the Cincinnati Board of Health on the toxicity of fluorides, and bibliography follow the report.

[ABSTRACTOR'S NOTE: The report was accepted by the Ministry of Health, which is preparing to implement it, according to notice in Journal of the American Water Works Association 46, No. 3:78 P and R, 1954.]

75. Anonymous: FLUORINE IN COLORADO SPRINGS WATER SUPPLY. Journal of the American Medical Association 154:1187 (Apr. 3), 1954; also (Long Experience with Fluorine in Water) American Journal of Public Health 44:431 (Apr.), 1954.

"At a meeting, Dec. 9, 1953, the El Paso County Medical Society, Colorado Springs, adopted the following resolution: 'Whereas, there is substantial evidence that the water supply of Colorado Springs has contained a surplus amount (2.6 parts per million) of fluorine for about 75 years; Be it resolved that during the long practice of medicine in Colorado Springs it is the considered opinion of the members of the El Paso County Medical Society that we have not experienced any clinical symptoms which can be attributed to the use of such water. It is known, however, that a condition known as 'mottled enamel' can be produced by the use of water containing an excess of fluorine.' "

76. Commission on Chronic Illness: FLUORIDATION OF WATER SUPPLIES ENDORSED BY COMMISSION AT ANNUAL MEETING. Chronic Illness News Letter 5, No. 4, 1954.

The statement, adopted by the Commission on Chronic Illness at its 5th annual meeting in 1954 on the effects of fluoridation of community water supplies upon the aged and chronically ill, defines dental caries as an important chronic disease "in terms of widespread prevalence and destruction of useful tissue — also important in the way that resulting loss of teeth may complicate the life of aged persons and persons suffering other disabling conditions."

Following the presentation of the report of a committee, under the chairmanship of Dr. K. F. Maxcy, requested to review and evaluate the available evidence on the safety of fluoridating water to 1 ppm, the Commission concludes as follows: "The Commission has been advised by the foregoing expert opinion that extensive research into the toxicology of fluorine compounds has revealed no definite evidence that the continued consumption of drinking water containing fluorides at a level of about 1 ppm is in any way harmful to the health of adults or those suffering from chronic illness of any kind. While the evidence does not absolutely exclude this possibility, if a risk exists at all it is so minimal and inconspicuous that it has not been revealed in many years of investigation. The Commission, therefore, urges American communities to adopt this public health measure as a positive step in the prevention of the chronic disease, dental caries.

"The fluoridation of water supplies involves no new experience in human welfare. Over 3,000,000 people are living in ordinary good health on water naturally containing fluorides in the amounts recommended for caries control, or more."

77. Editorial: FLUORIDATION, INDUSTRY, AND

OCCUPATIONAL HEALTH. Industrial Medicine and Surgery 23:431-2 (Sept.), 1954.

The editorial begins with the observation that if the long and well accepted practice of chlorination of community water supplies were being installed today as something new, the same sort of hue and cry over the measure would be raised by the uninformed people as that raised against fluoridation. Approval of fluoridation is expressed and various objections to the procedure are answered. The fear that in operations involving use of fluorides it would be more difficult to detect workers afflicted by industrial fluoride poisoning or that workmen would, by drinking fluoridated water, have just that necessary increment to bring about industrial fluoride poisoning that he might otherwise escape, is unwarranted, since the fluoride content of the drinking water would be a mere trifle compared with the much larger quantities required for industrial poisoning.

78. Hodge, H. C., and Smith, F. A. (University of Rochester, N. Y.): SOME PUBLIC HEALTH ASPECTS OF WATER FLUORIDATION. In: Shaw, J. H., Editor: Fluoridation as a Public Health Measure. Washington D. C., American Association for the Advancement of Science, 1954, pp. 79-109.

The important clinical effects of fluoride are carefully discussed. They are grouped into 4 categories:

	Dose frequency	Amount	Time	Clinical effect
Acute poisoning	Single	5 to 10 grams	2 to 4 hours	Death
Chronic high-grade poisoning	Daily	20 to 80 mg. or more	10 to 20 years	Crippling fluorosis
Chronic low-grade poisoning	Daily	2 to 8 mg. or more	Daily during 1st 8 years of life	Mottled enamel
Preventive dentistry	Daily	1 to 1.5 ppm in water	1st 8 years and later	Decreased dental caries

The factor of safety in water fluoridation (1 ppm) in relation to an acutely lethal dose is 2,500- to 5,000-fold in adults, and 250- to 500-fold in a child.

As to retardation of growth, based upon animal experiments (a table giving numerous species and concentrations at which inhibition of growth is generally present, or absent, and ranging from 10 to 6,500 ppm in ration, is presented) the safety factor is 50- to 100-fold; as to skeletal changes, 8- to 20-fold.

In the case of mottled enamel, the factor of safety is not large, but it is sufficiently great to permit a confident prediction that severe mottling in the form of stained teeth with grooved and pitted surfaces will not be seen. Although the margin of safety for mild mottling is only twofold, this safety factor is established firmly. The mathematical relationship between the severity of mottling and the level of fluoride in the drinking water gives an exceptional reliability to this prediction.

Because of the two potent detoxification mechanisms of the body, i. e., rapid excretion in the urine and rapid storage in the skeleton with subsequent mobilization and excretion, even if all the fluoride ingested in the drinking water (1 ppm) in a lifetime were stored in the skeleton, no injury would thereby accrue.

Apprehension as to whether an accident in a water treatment plant might produce dangerously high concentrations of fluoride is allayed by stating that if a day's supply were delivered over a period of an hour, the water would contain only 24 ppm fluoride, which could be taken daily for 10 years without serious difficulty. Also, for a city the size of Rochester, N. Y., to add to the water supply a sufficient amount to be acutely toxic, a total of 400 tons of fluorides would have to be added to the volume of water distributed daily; this is mechanically impossible, as the machine used has a hopper of 1,000-pound capacity.

The safety of water fluoridation is proved by the good health of populations drinking fluoride-containing waters and confirmed by extensive medical examinations in communities such as Newburgh.

79. New York, City of, Board of Health: REPORT TO THE MAYOR ON FLUORIDATION FOR NEW YORK CITY. L. Baumgartner, H. Emerson, P. R. Hays, S. Z. Levine, and T. M. Rivers, 1955, 52 pp.

The report submitted by the Chairman of the Board of Health of New York City includes the evaluation of the problem of dental decay, dental effects of fluoridation, possible harmful effects, alternative procedures for decay prevention, economics of engineering feasibility of fluoridation and legality of the measure.

In the summary statement, it is recommended that New York City's water supply should be fluoridated for the prevention of about 60% of the dental decay currently affecting all but a few percent of the population. Dental decay is a true health hazard, accounting for the major portion of the population's annual dental bill of over $100,000,000.

In considering other methods of caries prevention, educational efforts toward dietary control and toothbrushing after eating have been unsuccessful; periodic application of fluoride solutions to teeth offers about 40% caries reduction, but is costly and demands trained professional personnel. In considering ingestion of fluoride, it is pointed out that even though fluoride occurs in human nutrition, it is only with the additional fluoride obtained from water that substantial dental benefit has been achieved. No other procedure approaches water fluoridation in dependable effectiveness in protection, maintained at least through age 45 and probably throughout life.

At a fluoride concentration of 1 ppm in water, the margin of safety is great. The lowest concentration producing any undesirable effect is about 2 ppm, at which level a proportion of the population show mottled enamel. It is considered significant that a community (Colorado Springs), with 2.6 ppm in its water for generations has not reduced the fluoride content of its water supply.

After evaluating the practicality of fluoridation, from the cost and engineering points of view, the annual maintenance cost, including the chemical, would be about 9 cents per capita.

Exhibit 1, appended to the report is a letter from H. V. Smith of the University of Arizona who had earlier advocated a "go slow" attitude on fluoridation based on observations of mottled teeth in southern Arizona children ingesting fluoride in a concentration of 0.9 ppm. As the result of a visit to Newburgh, N. Y., he has decided to withdraw his objection, provided careful preliminary studies are made to determine the safe amount of fluoride for the area concerned, as it has become apparent that mottling occurs in Arizona by higher water consumption because of hot climate.

In Exhibit 2, G. J. Cox points out, on the basis of personal experience, the unreliability of adequate intake of fluoride by children when fluoride tablets are used to make up fluoridated water in individual homes.

80. Committee to Protect Our Children's Teeth, Inc. (B. Spock, Chairman): OUR CHILDREN'S TEETH; A DIGEST OF EXPERT OPINION BASED ON STUDIES OF THE USE OF FLUORIDES IN PUBLIC WATER SUPPLIES. Submitted to the Mayor and the Board of Estimate of the City of New York, March 6, 1957, 104 pp.

The statements by scientific authorities are summarized as follows:

H. E. Hilleboe (Commissioner of Health, State of New York): "The progressive accumulation of dental disease is a national calamity. Water fluoridation is an extension of standardized water treatment procedures designed to improve the health of consumers."

H. T. Dean (Secretary, Council on Dental Research, American Dental Association): "Fluoridation is a proven, effective, cheap and safe method for the partial control of dental caries."

T. Parran (Former Surgeon General): "Scientific evidence suggesting it (fluoridation) was much more complete 10 years ago than has been the scientific evidence for the majority of community health programs when they were started. New York City has a proud record of pioneering in public health. Why should it be lagging?"

F. A. Arnold (Director, National Institute of Dental Research): "The reports present conclusive evidence of the effectiveness of the procedure in reducing dental decay."

T. J. Hill (Chairman, Council on Dental Research, American Dental Association): "At one part per million there is no observable mottling of the teeth."

R. A. Kehoe (Director, Kettering Laboratory): "The question of the public safety of fluoridation is non-existent from the viewpoint of medical science."

D. W. Bronk (President, National Academy of Sciences): "As President of the National Academy of Sciences, I have full confidence in the integrity, reliability and scientific competence of these reports. As a scientist who has for many years had an opportunity to view the great contributions of disinterested, scientific investigations and deliberations to the furtherance of human welfare, I am a firm believer in the importance of depending on unbiased opinions based on carefully considered evidence."

[The following authorities submitted statements based on their investigations as described in abstracts contained in this bibliography: D. B. Ast, Director, New York State Bureau of Dental Health, Abstract No. 100; A. L. Russell, Chief, Epidemiology and Biometry, National Institute of Dental Research, Abstract No. 95; F. J. McClure, Senior Nutritionist, Abstract No. 29; E. R. Schlesinger, Associate Director, New York State Division of Medical Services, Abstract No. 42; N. C. Leone, Chief, Medical Investigation, National Institute of Dental Research, Abstract Nos. 35 and 37; T. L. Hagan, Assistant to the Chief Dental Officer, U. S. Public Health Service, Abstract No. 57; R. F. Sognnaes, Professor of Oral Pathology, Harvard University, Abstract No. 107.]

The Nation's foremost chemists state that the fluoride ion dissolved in water whether above or below ground, is the same as the fluoride ion in water when fluorides are added under good chemical and engineering control to prevent dental caries, so that there is no difference in its effect in the human body.

The history of fluoridation in various large cities is discussed by the officials of these cities. The legality of fluoridation is discussed by B. M. Webster, Counsel to the Committee.

The following national organizations have adopted policies favorable to fluoridation: American Cancer Society; American Nurses Association; American Hospital Association; Federal Civil Defense Administration; U.S. Department of Defense; U. S. Army, U. S. Navy, U. S. Air Force; American College of Dentists; Conference of State Sanitary Engineers; American Pharmaceutical Association; American Association for the Advancement of Science; National Institute of Municipal Law Officers; American Society of Dentistry for Children; American Dental Association; American Medical Association; American Academy of Pediatrics; American Public Health Association; American Public Welfare Association; American Water Works Association; American Institute of Baking; American Institute of Canning; American Society of Brewing Chemists; American Association of

Public Health Dentists; State and Territorial Health Officers Association; State and Territorial Dental Health Directors; U. S. Department of Health, Education, and Welfare: Food and Drug Administration, Public Health Service, National Institutes of Health; National Research Council; The Johns Hopkins University: School of Hygiene and Public Health; University of Pittsburgh: School of Public Health; Association of Casualty and Surety Companies; The Travelers Insurance Company; Inter-Association Committee on Health: American Dental Association, American Hospital Association, American Medical Association, American Nurses Association, American Public Health Association, American Public Welfare Association; Commission on Chronic Illness; National Congress of Parents and Teachers; American Legion; U. S. Junior Chamber of Commerce; American Federation of Labor and Congress of Industrial Organizations; American Society of Clinical Pathologists; Child Study Association of America; College of American Pathologists; Industrial Medicine Association; American Dental Hygienists Association; American School Health Association; Joint Committee on Health Problems of the American Medical Association and the National Education Association.

81. New Zealand Commission of Inquiry: REPORT OF THE COMMISSION OF INQUIRY ON THE FLUORIDATION OF PUBLIC WATER SUPPLIES. Report H. 47. Wellington, New Zealand, Government Printer, 1957, 240 pp.

The Commission to inquire into the desirability or otherwise of the fluoridation of public water supplies, with Wilfred Fosberrey Stilwell, Chairman, Norman Lowther Edson and Percy Vernon Esmond Stainton, members, was appointed by Governor General C. W. M. Norrie in November, 1956. The report was presented on July 10, 1957, following an extensive review of the literature, including that of the opponents to fluoridation, correspondence, and 5 public hearings.

The details are presented in 12 parts, including the introduction. In reviewing the various aspects, the statements made by opposing witnesses at hearings are introduced into the text, as are publications by the leading opponents. These are answered on the basis of reliable literature and correspondence with world authorities with experience in the subject.

The dental health problem in New Zealand is emphasized. Virtually every child born there experiences dental decay; 46% of children aged 2 have decayed deciduous teeth, and at age 7, 94% of the children are affected. In consequence, an unduly high proportion of the population over the age of 21 years uses some form of denture. Consequences of dental decay are spread of the infection to the tooth socket and jaw bones, soft tissues of the face and neck, and other kinds of ill health in certain cases. The pain and discomfort of toothache affect efficiency, and loss of teeth causes in some psychological problems. Efforts toward dental health education have shown the effectiveness of this to be questionable, and the conclusion, in spite of assertions by opponents to fluoridation, is that there is no hope that such a program will achieve a significant beneficial effect.

The relation of fluoride to dental health, its mode of action in preventing decay, and its effectiveness are reviewed. Some criticisms of the effectiveness of fluoridation and answers to them are presented. The probability of substantial reduction of dental decay, equaling that seen in study areas in the United States and Canada, by the addition of fluoride in New Zealand, where the fluoride content of public water supplies ranges generally from 0. 05 to 0. 5 ppm, is predicted.

The incidence and degrees of dental fluorosis with higher concentrations of fluoride are reviewed. No connection has been found in the incidence of periodontal diseases or of the tooth pulp with the ingestion of fluoride-containing water.

The behavior of fluoride in the body including its toxicity were studied carefully and any possibility of acute or chronic poisoning, or of fluoride acting as an enzyme poison at optimum levels, was discarded.

The medical questions were given particular attention with the conclusion that fluoridated water does not cause or aggravate any of the following disorders: of the brain and nervous system, of the special senses, and of the mind; of the heart and blood vessels; of the kidney and urinary tract; cancer; diabetes or those of the thyroid gland; of the gastrointestinal tract and the liver; of pregnancy and labor or developmental defects in children; of bones, joints, and of the bone marrow; irritation of the eyes or of the mucous membranes. The "Spira-Waldbott syndrome" is summarized as follows: "The signs and symptoms of the alleged syndrome may be due to any number of unrecognized causes and there is no causal relationship between any of these signs and symptoms, and the ingestion of water containing 1 ppm of fluorine and food cooked in this water."

The general conclusions concerning health are that fluoridation does not add a substance that is foreign to the water, that it is a normal constituent of teeth and bones, that no diet is devoid of it, and that no harmful effects will follow whether in respect to the complaints specifically made to the Commission or otherwise.

The review of engineering, chemical, or mechanical aspects satisfied the Commission to recommend that "standard specifications should be introduced dealing with all aspects of the treatment of water supplies with fluoride; a supervisory and controlling body should be set up on a national basis with authority to ensure that all proposed plants conform to the standards laid down."

Alternatives to fluoridation of water supplies were considered and it was concluded that "no alternative suggested would be effective as a public health measure, (and that) there is no practicable method of adjusting the daily intake of fluoride other than by addition of that substance to public water supplies."

The personal rights were examined, concluding that no question of personal liberty arises in regard to fluoridation; the avoidance of fluoridated water might cause inconvenience, but in no case would its use be compulsory.

As to the position of local authorities, it is the opinion that "a decision to fluoridate public water supplies should be left to the communities concerned; a referendum or local body poll is an unsatisfactory method of reaching a decision on a technical and complex question such as fluoridation .... (and) the special order procedure described in ... the Municipal Corporations Act 1954 should be followed by all local authorities proposing to fluoridate public water supplies."

The general conclusions were that the Commission is "satisfied that widespread use should be made of the fluoridation process for the purpose of achieving an urgently needed improvement in the present serious state of dental health in New Zealand."

The appendixes include a bibliography; tabulations of the following: findings of dental decay in New Zealand, fluoride concentrations in enamel from areas with varying fluoride in water supplies, reduction of dental decay obtained in Grand Rapids, Brantford, Canada, and Newburgh, fluoride content of public water supplies, prevalence of dental fluorosis and idiopathic enamel defects; list of exhibits produced at public hearings and of persons appearing at them, or by letter subsequent to them; and an extract from "Hawke's Bay Herald-Tribune" in 1951, on the occasion of Hastings being chosen as an experimental community for fluoridation of its water supply, with Napier to serve as the control town. A detailed combined subject and author index completes the report.

82. World Health Organization: EXPERT COMMITTEE ON WATER FLUORIDATION. FIRST REPORT. Technical Report Series No. 146, Geneva, 1958, 21 pp.

The Executive Board, by resolution (EB21.R6, Off. Rec., World Health Organization 83:7, 1958), noted the report of the Expert Committee on Water Fluoridation and authorized its publication. The summary states that dental caries is one of the most prevalent and widespread diseases which cannot be controlled by present treatment methods alone. Fluoridation of drinking water at 1 ppm of fluoride is the most promising of the preventive measures. Its effectiveness, safety, and practicality have been established by epidemiologic studies conducted in areas where fluoride occurs naturally and where it has been added by mechanical means.

The literature on the biological effects is extensive and of broad scope. No evidence of enzyme inhibition has been found in persons drinking water containing concentrations of fluoride optimal for dental health. Adequate factors of safety guarantee the absence of changes reported to result from excessive ingestion of fluoride when water containing 1 ppm fluoride is drunk. There is no evidence of kidney injury or of any effect on concurrent kidney disease in populations drinking water containing up to 5 ppm fluoride. No relation between thyroid dysfunction and naturally fluoridated water has been established, and in humans, 1 to 5 ppm fluoride is without demonstrable effect on thyroid. Growth and development, somatic and psychic, are normal in children drinking water with 1 ppm fluoride. Large population groups have, during their lifetime, consumed water containing 1 ppm and more. Mortality and morbidity rates for 5 leading causes of death are comparable for cities in the United States of America with fluoride and nonfluoride water supplies. No relation between fluoride and arthritic changes in bone has been found, and no confirmed cases of allergy to water containing 1 ppm fluoride have been described.

Suitable equipment has been developed for the addition of fluoride, reliable analytical procedures are available, and appropriate safeguards have been established.

No other vehicles or techniques for the prophylactic application of fluoride can, at present, replace fluoridation as a public health measure. Where it cannot be used, research into other vehicles and improved methods of local application should be encouraged.

It is concluded that controlled fluoridation of drinking water is a practicable and effective public health measure.

83. Anonymous: DENTISTS IN SOUTH AFRICA SUPPORT FLUORIDATION. Journal of the American Dental Association 61:623 (Nov.), 1960.

The Dental Association of South Africa adopted a motion to support the principle of fluoridation of water supplies at the scientific optimum as a health measure and to pass on this decision to all public health authorities, etc., and to the Minister of Health. It also rejected an attempt to amend the motion to withhold support for fluoridation "until adequate statistical treatment of all the pertinent factors has been carried out."

84. Ontario Province, Canada: REPORT OF THE COMMITTEE APPOINTED TO INQUIRE INTO AND REPORT UPON THE FLUORIDATION OF MUNICIPAL WATER SUPPLIES. Toronto, Ontario, Jan., 1961, 177 pp.

In 1959, a committee was appointed to inquire into the fluoridation of public water supplies. This measure has been a subject of public controversy in the Province of Ontario since 1957, when the Supreme Court of Canada, in the case of Metropolitan Toronto vs. Village of Forest Hill, decided that Metropolitan Toronto under legislation existing then lacked the power to enact a bylaw providing for it.

Before the judgment was announced, the Legislature amended the Public Health Act authorizing 8 municipalities which were already fluoridating to continue to do so. These were: City of Brantford, Town of Brockville, Town of Deep River, Town of Fort Erie, City of Oshawa, Town of Thorold, Township of Tisdale and City of Sudbury.

The committee then proceeded with having a review of the literature done by qualified people, by holding in 1960 a series of 10 public hearings which included the presence of opponents, examining and hearing all available evidence on the basis of reports, correspondence and interviews with experts, by questionnaires and surveys.

The report deals with the following aspects in addition to reporting details of the above-mentioned aspects: Dental caries as a health problem in Ontario; fluoride and dental caries relationship; the role and toxicity of trace elements in nutrition; action of fluoride in the body; effects of prolonged exposure to fluorides; evidence in Ontario of the effectiveness in caries prevention on the basis of the Brantford-Sarnia-Stratford study, and of the health of residents in fluoride areas; mechanical and economic aspects; other forms of fluoride administration; civil rights.

As there are many areas in Ontario where the water supply contains fluoride at levels of 1 ppm or more, the Medical Officers of Health of these counties were consulted. Comments were that: no ill effects have been observed, even though the fluoride content of some waters ingested is as high as 4 ppm; there have been no complaints of discoloration or mottling of teeth at concentrations of around 1 ppm; continual perusal of death certificates and morbidity reports from hospitals and physicians has revealed no deleterious effects by waterborne fluoride, present naturally or added; thousands of X rays read at the Niagara Peninsula Sanatorium which included patients from fluoride-bearing regions revealed no evidence of fluoride deposition in bone. Further, comparison of mortality rates for all causes, stillbirths and infant mortality in 18 cities that had water supplies with 1 ppm or more fluoride with 18 fluoride-deficient cities and for Stratford, Brantford, and Sarnia, by Dr. C. Buck and A. H. Sellers of the Ontario Department of Health, showed variations within the two groups to be greater than between them and not influenced by the fluoride content of the water.

Appendixes include among other data, the amounts of natural fluoride in some municipal waters in Canada, and civil rights and fluoridation in the United States.

The conclusions reached by the committee include the following: Dental caries in Ontario is a major problem and the adequate treatment of it is beyond the resources of the dental profession; treatment alone will not control or reduce the ultimate incidence of tooth decay; the importance of good oral hygiene and of proper nutrition as well as the limitations or inadequacy of both are realized; the value of prevention, rather than treatment; the reduction of dental caries by fluoride during the period of tooth development extending into adulthood; the fact that at about 1 ppm, fluoride ingestion is not harmful; mechanical adequacy of fluoridation equipment and control of concentration of fluoride in the water; lack of effect on mechanical equipment and industrial processes; low cost for community benefit; lack of practical alternative; fluoridation is not denial of any fundamental or basic civil right or liberty that the Legislature of Ontario should preserve.

The Committee unanimously recommended that: Legislation be enacted empowering municipalities to fluoridate their water supplies; such legislation should authorize municipalities to introduce fluoridation by bylaw without the necessity of a referendum; legislation be enacted authorizing the fluoridation of water supplies which are not controlled or operated by municipalities; the appropriate departments of the Ontario Government should keep under constant review alternatives to fluoridation of municipal water supplies which may prove feasible for people living in areas not served by communal water systems; a sound, concerted program supplying accurate nutritional information to the people of Ontario as part of a total program of general health and dental health education, be implemented.

[ABSTRACTOR'S NOTE: A summary of the report was published as an Editorial in the Canadian Journal of Public Health 52:165-8 (Apr.), 1961. Included in this Editorial is the statement that "a bill to implement the recommendations of the report was passed by the Ontario Legislature at the session which has just closed. The bill grants authority to municipalities in Ontario to provide fluoridation and without the holding of a referendum. It provides, also, however, that on a petition signed by ten per cent of the citizens a referendum may be held. Municipalities may now move to provide fluoridation and it is expected that communities that have been waiting will proceed with this valuable health measure."]

85. Great Britain, Ministry of Health, Scottish Office, Ministry of Housing and Local Government: THE CONDUCT OF THE FLUORIDATION STUDIES IN THE UNITED KINGDOM AND THE RESULTS ACHIEVED AFTER FIVE YEARS. Reports on Public Health and Medical Subjects No. 105. London, Her Majesty's Stationery Office, 1962, 50 pp.

In 1952, on the recommendation of the Medical Research Council, the British Government sent a mission to the United States to study fluoridation and to advise whether fluoride should be added to fluoride-deficient water supplies in the United Kingdom (see Abstract No. 74). The mission concluded that fluoridation of water supplies was a valuable health measure, but recommended that fluoride be added in some selected areas before its general adoption in Great Britain. In view of the differences in British eating and drinking habits from those in the United States, preliminary studies were done to determine whether the greater ingestion of tea would result in a fluoride intake greater than from the usual diet. These studies showed that in the case of children, 5 to 14 years old, the average daily ingestion of fluoride, whether the drinking water contained no fluoride or had a fluoride content of 1 ppm, was the same as in America, or 0.6 and 1.2 milligrams (mg.) of fluoride per day (see Abstract No. 46). In the case of adults, the daily fluoride intake for men and women of 3.2 and 2.2 mg., respectively, taking into account the consumption of tea when water containing 1 ppm fluoride is used, was considered to be well within the safe limit in view of the reports on the health of Bartlett residents who used water with a fluoride content of 8 ppm.

Surveys of the dental health of children, begun in 1954 in Great Britain in areas of differing fluoride content, also gave values similar to those obtained in the United States.

The areas selected for study in Great Britain were Watford in Hertfordshire, part of the County of Anglesey, and Kilmarnock in Ayrshire. The control areas were Sutton in Surrey, the remainder of the County of Anglesey, and the County Town of Ayr, respectively. Watford and Sutton which have populations of almost 80,000 are within a few miles of London and are largely residential. Kilmarnock and Ayr are mainly industrial with about 43,000 residents. Two other study areas planned did not materialize.

Fluoridation began in Anglesey in November, 1955, in Kilmarnock in April, 1956, and in Watford in May, 1956, and a concentration of 0.9 to 1.0 ppm has been maintained consistently in all three areas. Dental examinations were begun in 1955 and repeated annually. The technical details of the addition of fluoride were carefully worked out.

The results after 5-1/2 years of fluoridation, in 1961, in comparison with the base-line years, show reductions amounting to 66% in the 3-year-old children, 57% at 4 years and 50% at 5 years of age. In children of 6 and 7 years whose teeth had not had the full benefit of fluoride, the reductions were 26 and 14%, respectively. The proportion of children in the fluoridated areas with 10 or more carious teeth has also been markedly reduced. While in the control areas also reduction in caries was observed, this was of the order of 2 to 7% for children aged 3 to 7 years, and not considered of consequence.

The results for the children 4 and 5 years old are comparable to results obtained in N. America, and there is good reason to expect that the longer term effects of fluoridation will be similar to them.

The Research Committee which had reviewed the work begun by the Steering Committee, continued the surveillance of the safety of fluoridation through general practitioners in the study areas, by analysis of vital statistics, and by investigations on samples of populations in areas with different levels of fluoride in the water supply to test specific hypotheses or allegations of harm. The conclusion reached is that no harmful effects from the addition of fluoride to drinking water to bring the concentration to 1 ppm have been demonstrated in any of the extensive evidence collected and reviewed. In the opinion of the Committee, the general raising of the fluoride content in drinking water to this level is safe.

The appendixes cover the following detailed tables and reports: Dental survey in the natural fluoride areas in Great Britain; fluoride intake from the diet; fluoridation equipment and chemicals; methods of fluoridation in each of the study areas; control of the level of fluoride in the water supplies of the study areas; dental examinations and comparison with American findings.

Appendix 8 is devoted to the summary of an extensive program of medical vigilance in the study areas. The approach was:

(1) To general practitioners in the study areas, with a consultant physician to be available, followed, if necessary, by hospital accommodation under the National Health Service. Of 89 doctors familiar with the pattern and course of disease in their practices and some outside to provide them with comparison, who had been questioned repeatedly, only one reply, from an obstetrician concerning anemia, called for investigation. The incidence of anemia was not related to the water supply.

(2) Through vital statistics: no indication was found that at the levels encountered naturally in British waters, 0.4 to 5.8 ppm, fluoride has any effect on mortality as determined from statistics of the General Register Office. Death rates from major causes of death were the same as in areas where fluoride was present at less than 0.2 ppm.

(3) By specific investigations: osteochondritis juvenalis of spine (see Abstract No. 45); accumulation of fluoride in bone (see Abstract No. 51); malnutrition and dental mottling; incidence of mongolism (see Abstract No. 48); incidence of peptic ulcer (this was not found to be increased following fluoridation); absenteeism from school (not affected by fluoridation).

The review of the evidence gives assurance that there are no reports of harm from local doctors; that vital statistics indicate no adverse effects; that specific investigations show no effect before birth (mongolism), in infancy, childhood, or adult life (such as kidney disease, thyroid enlargement, or other effects).

The opinion of the Ministry's Research Committee, as summarized, is that the raising of the fluoride content of drinking water to a level of 1 ppm is safe.

[ABSTRACTOR'S NOTE: The following notice is published in the Dec. 15, 1962, issue of the Lancet (II:1264): "Mr. Enoch Powell, Minister of Health, announced in Parliament last Monday that, under section 28 of the National Health Service Act, he will approve schemes submitted to him by local health authorities for arranging with water undertakers to add fluoride to water-supplies where these are deficient in it. The Secretary of State will be applying the same policy in Scotland." From 60 to 70 local authorities had already expressed interest in this preventive health measure, and Mr. Powell believed that with this Governmental approval, the scheme would now go ahead quickly.]

86. International Association for Dental Research: PROCEEDINGS OF THE FORTIETH GENERAL MEETING, ST. LOUIS, MISSOURI, MARCH 15-18, 1962. Journal of Dental Research 41:919-38 (Sept./Oct.), 1962.

The following resolution was adopted by the Council of the International Association for Dental Research at its 40th general meeting, 1962, and subsequently approved by the Association membership at the final executive session:

Resolved, That the International Association for Dental Research declares that fluoridation of community water supplies is a scientifically sound procedure and urges that it be speedily instituted by all communities that have not yet done so, and be it further

Resolved, That the following statement of policy be adopted by the International Association for Dental Research:

"The International Association for Dental Research has been established to promote the advancement of research in all branches of science related to oral health and disease, that dentistry may continue to improve its service to humanity. One of the most notable fruits of dental research has been the discovery that the fluoridation of public water supplies extends to those drinking such water lifelong, safe, and significant protection against dental caries. It is the conviction of this Association that such a scientifically sound procedure ought to be instituted speedily by all communities that have not yet done so."

87. Smith, F. A. (University of Rochester, N. Y.): SAFETY OF WATER FLUORIDATION. Journal of the American Dental Association 65:598-602 (Nov.), 1962.

Periodic reviews of the recent literature give evidence that water fluoridation for the reduction of dental caries is a safe public health measure.

The factors of safety inherent in water fluoridation, as estimated by Hodge and Smith in 1954 (see Abstract No. 78) are further substantiated in the present review.

Studies of the metabolism of fluoride, particularly those with the aid of radioactive fluoride confirm the finding that of the fluoride absorbed, roughly half is eliminated in the urine, and half is stored in the bone; that there is no storage of fluoride in soft tissue, and that elevated amounts reported to be present in the placenta and in the aorta probably accumulate there in small loci of calcification. Recent investigations give no evidence of a positive relation between fluoride intake, malnutrition and spinal defects. Speculation that drinking fluoridated water would lead to precipitation of radioactive strontium fluoride in the skeleton is physiologically impossible. Further, there is no relation between strontium and fluoride in the teeth, nor between strontium levels in teeth and concentrations of fluoride in the drinking water, nor between the metabolism of strontium and that of fluoride.

As concerns the effects on growth, a review of more than 300 studies with 13 different species of animals at concentrations of fluoride up to 6,000 ppm for periods ranging up to 5 years shows that the safety factor for water fluoridation remains 50- to 100-fold.

Review of the effects of fluoride on reproduction in long-term studies with animals reveals that amounts below 60 ppm in the diet cause no interference.

That no adverse effects on the heart and circulation are to be expected from water fluoridation is evident from thorough investigations of residents of Newburgh and Kingston, and of Bartlett and Cameron, as well as examination of vital statistics from other areas. Concern may have been aroused by experiments with dogs whose blood pressure was depressed and heart rate and femoral blood flow increased by administration of fluoride by stomach tube. However, it has been demonstrated that decreases in blood pressure are produced by merely introducing a stomach tube into the dog; experiments with dogs in which larger doses were injected intravenously, showed no effect.

The hematopoietic system is very sensitive to many factors, such as dietary deficiencies, infections, chronic illness, and others, which may well account for occasional reports that fluoride has a deleterious effect on the blood and blood-forming organs. Many investigations reveal no effect on the hematopoietic system of experimental animals by dietary fluoride at less than 100 ppm; blood examinations in Newburgh and Bartlett have shown no differences from the control cities.

No changes of the kidney have been found in experimental animals fed water containing fluoride at 50 ppm. Changes in the kidney of rats attributed to water containing 1, 5 or 10 ppm fluoride, as reported by Ramseyer, could not be repeated; the changes seen were those usually found in aged rats and were not attributable to fluoride.

Concerning effects on the thyroid gland, in spite of a volume of conflicting literature on the subject, there is no relation between the incidence of goiter, use of iodine to control goiter, or ability to take up iodine, and fluoridated water.

Finally, there is a twofold safety factor between the level of fluoride causing enamel hypoplasia and the optimal level for caries reduction.

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 3, 4, 5, 6, 7, 9, 16, 20, 24, 94, 104, 131, 132, 137, 153.

5. FLUORIDE AND DENTAL HEALTH

Fluorine is not unique among the elements occurring naturally in the environment — and therefore in living organisms — that have attracted the serious attention of investigators by their undesirable effects before the universality of their occurrence and their beneficial function were fully recognized. The history of fluorine is a fascinating one, for its presence, in combination with other elements or in ionic form, in minerals, soil, water, animal and human tissues was known long before the element could be isolated in its elemental form. Furthermore, its essential role in dental health was suggested almost ninety years ago, after the acute toxicity of its compounds became known. There is nothing unusual in this. Virtually all elements, even the most vital, such as oxygen, iron, manganese, chlorine, and others, are highly toxic in their elemental or combined form if exposure to them is great enough.

The story of the investigation of mottled enamel, and the simultaneous recognition that the teeth of people living in these areas were resistant to decay, is excellently told by McKay (Abstract No. 88) and Dean (Abstract No. 91). Dean and his associates were responsible for extensive and thorough investigations before the advisability of adding fluoride to fluoride-deficient waters was realized first through carefully controlled studies in selected communities, then by request of populations of various cities.

Ideally, publications concerning the control of dental caries with waterborne fluoride at optimum concentrations and those dealing with observations of mottled enamel should be segregated. This, however, is impractical because of their intimate historical connection. In fact, the precise recognition of the concentrations of fluoride in water exerting desirable and undesirable effects on teeth, which is so evident in the careful investigations of Dean and others, should give further assurance of the soundness of fluoridation of water supplies from the point of view of health and of the prevention of dental caries.

A. CONTROL OF DENTAL CARIES BY WATERBORNE FLUORIDE

88. McKay, F. S. (Colorado Springs, Colorado): MOTTLED ENAMEL: EARLY HISTORY AND ITS UNIQUE FEATURES. In: Moulton, F. R., Editor: Fluorine and Dental Health. Washington, D. C., American Association for the Advancement of Science, 1942, pp. 1-5.

The study of mottled enamel, a lesion long recognized in Colorado Springs and certain adjacent areas, originated as a research project in dental science in 1908. It had never been reported in the dental literature, so that the investigation began without anything that could be used as a guide. As the manifestation was limited to children and young adults, schools of Colorado Springs were surveyed; it was found that it occurred only in individuals native to the community or who had established residence there during early infancy; also children born elsewhere who had established residence in the community during the period of enamel calcification of certain teeth showed mottling on all such teeth and on those that calcified subsequently within the community. Enamel completely calcified, before the change of residence, was normal and remained so. Except under the most unusual conditions, deciduous teeth were not affected. Therefore, it was evident that something peculiar to the community was the cause.

The next step was to define the geographical boundaries and the responsible agent. The only point of difference of afflicted and nonafflicted districts was the drinking water. Dr. G. V. Black joined the investigation, and the first article in dental literature on the subject was published in 1916, * although a very brief reference to what seemed to be the same condition near Naples, Italy, had been published in 1902 by Eager. **

With the aid of Grant No. 1 from the new Dental Research Fund of the American Dental Association, McKay began extensive investigations. Although the association of drinking water from deep wells with mottled enamel became soon established, the specific substance causing it did not become known until 1931 when Churchill, chief chemist of the Aluminum Company of America, found fluoride, then considered an unusual constituent of water, in the deep well water of Bauxite, Arkansas. Subsequently, Churchill analyzed the water from 6 areas where mottled enamel was found and from some 30 municipalities of the United States where it did not exist. The results were published in Industrial and Engineering Chemistry 23:996-8, 1931, and at the same time, M. C. Smith of the University of Arizona, came to similar conclusions concerning mottled enamel observed by her in Arizona communities (Abstract No. 89).

Even before this discovery of fluoride, investigations in Oakley, Idaho, and Bauxite, Arkansas, had proved the drinking water to be the causative agent. In Oakley, *** where 100% of the native population showed mottled enamel at the first examination, the water supply was changed to another source, because the children of the family using the latter had shown no dental mottling. Bauxite had done the same thing. After 8 and 10 years, respectively, re-examination of the population of the two towns showed no further production of mottled enamel. Analyses of the new waters showed the absence of fluoride.

While the early investigations had been intended to find the cause of mottled enamel and means of preventing it, an unexpected finding was that fluoride in some way exerts an inhibitory influence on dental caries attack. McKay regrets that more refined examinations had not been made from the start of the investigations, but at that time, he intended only to convey the information that mottled enamel was not rendered more liable to decay because of its defective calcification. More recent investigations have furnished conclusive evidence that caries attack rate is markedly less in certain towns where the water contains fluoride than in fluoride-free towns. Hence, in his belief, the findings have extended responsibility to water works engineers and chemists to determine the fluoride content of new sources of water for municipal use or the augmentation of existing supplies.

Facts of fundamental importance established through the investigation are: (1) lesions affecting the integrity of enamel can be produced only during the period of calcification and not thereafter; (2) such lesions, once incurred, are never repaired; (3) fluoride is the only agent in the diet capable of modifying the structure of the enamel; (4) dietary elements are incapable of producing any alteration of the structure of enamel after calcification has been completed.

*Black, G. V., in collaboration with F. S. McKay: "Mottled Teeth: An Endemic Developmental Imperfection of the Enamel of the Teeth Heretofore Unknown in the Literature of Dentistry," Dental Cosmos 58:129-56, 1916.

**Eager, J. M.: "Chiaie Teeth," Dental Cosmos 44:300-1, 1902.

***Dean, H. T., and McKay, F. S.: "Production of Mottled Enamel Halted by a Change in Common Water Supply," American Journal of Public Health 29:590-6, 1939.

The geographical distribution of mottled enamel is reported in the following articles: McKay, F. S.: "The Present Status of the Investigation of the Cause, and of the Geographical Distribution of Mottled Enamel, Including a Complete Bibliography on Mottled Enamel," Journal of Dental Research 10:561-8, 1930; Dean, H. T.: "Geographical Distribution of Endemic Dental Fluorosis (Mottled Enamel)," (Abstract No. 1).

89. Smith, H. V., and Smith, M. C.: MOTTLED ENAMEL IN ARIZONA AND ITS CORRELATION WITH THE CONCENTRATION OF FLUORIDES IN WATER SUPPLIES. University of Arizona Agricultural Experiment Station, Technical Bulletin No. 43: 213-87 (July 15), 1932.

A survey disclosed about 45 towns or rural districts in Arizona in which mottled enamel is endemic. Analysis of 110 public and 75 private water supplies showed a fluoride content ranging up to 12.6 ppm. Most of the affected places lie along the Gila and the San Pedro Rivers. The fluoride content could not be correlated with the depth and type of well. Rock phosphates containing 3 to 4% fluoride (30,000 to 40,000 ppm) are widely distributed in Arizona.

Moderately severe and severe mottling was found where the water contained more than 5 ppm fluoride; mild to moderately severe type was seen where water contained 2.7 to 5 ppm. Evidence indicated that waters having a concentration of 2 ppm or less do not interfere with normal development of the enamel to the extent of causing observable mottled enamel, while 2 to 3 ppm seemed to be the borderline range causing mottling in some individuals but not in others.

[ABSTRACTOR'S NOTE: In their earlier publication ("The Cause of Mottled Enamel, a Defect of Human Teeth," University of Arizona Agricultural Experiment Station, Technical Bulletin No. 32:253-82, 1931), M. C. Smith, E. M. Lantz, and H. V. Smith report on their correlation of the occurrence of mottled enamel in St. David, Arizona, with the fluoride content of the drinking water. Proof was obtained by them in animal experimentation and analyses of the St. David waters which contain fluoride in amounts ranging from 3.8 to 7.15 ppm. Although in their first experiments rats maintained on adequate diets showed no destructive effects on teeth when given the St. David drinking water, a deficient diet plus the St. David drinking water did produce observable changes in the incisors. When the St. David water was concentrated to 1/10 the original volume, and given to the rats to drink, or when the residue was incorporated into their food, the rats developed an enamel dystrophy similar to if not identical with the mottling of human teeth.]

90. Dean, H. T. (National Institute of Health): THE INVESTIGATION OF PHYSIOLOGICAL EFFECTS BY THE EPIDEMIOLOGICAL METHOD. In: Moulton, F. R., Editor: Fluorine and Dental Health. Washington, D. C., American Association for the Advancement of Science, 1942, pp. 23-31.

SUMMARY: Epidemiology as applied to dental fluorosis is defined, and the calculation of the dental fluorosis index is explained.

The term "epidemiological method" refers to the procedure employed in the study of a disease or a condition as a mass phenomenon in contrast to the clinical method. The population, rather than the individual, is the unit of investigation.

In applying the epidemiological method to a physiological problem, endemic dental fluorosis, the aspects discussed include the fact that this is essentially a waterborne disease associated with the ingestion of fluorides present in the water used for cooking and drinking during the period of enamel calcification of the affected teeth; certain of the deciduous teeth may be affected in areas of medium to high fluoride concentrations.

Requisites for quantitative evaluation are a common water supply with no change during the period the group lived in the area, and a population using it continuously throughout life of a size large enough to permit the selection of a representative sample of individuals, preferably 12 to 14 years of age, or an age group in whom a high percentage (about 94%) of the permanent teeth has erupted.

Recording quantitatively the degrees of severity each tooth is affected, is done by a classification of 6 groupings, and by use of a numerical index giving a definite weight to each classification: These are, 0 - normal; 0.5 - questionable (enamel showing slight aberrations from the translucency of normal enamel); 1 - very mild (small, opaque, paper white areas scattered irregularly over not more than 25% of the tooth surface); 2 - mild (these white areas scattered over less than 50% of the tooth); 3 - moderate (all surfaces of the tooth are affected and show marked wear, frequently with brown stain); 4 - severe (all surfaces are affected, hypoplasia so marked that form of tooth may be affected; major signs are discrete or confluent pitting, widespread brown stains).

The index for a community is figured by dividing the total sum of the products of the weight of each classification (0 to 4), times the number of individuals in whom it was found (frequency), by the total number of individuals examined. For instance, in Amarillo, Texas, the sum of the products of the weights times the frequency was 661.5 and the number of children examined, 289, giving an index of dental fluorosis of 2.3.

The fluoride content of public water supplies (representing a mean of 12 monthly samples determined by the Elvove method) of 22 cities in 10 states, in correlation with the indices as obtained on 5,824 white children, is tabulated. The percentage distribution of the various classifications is also shown.

The association between the index and the fluoride concentration of the water supply followed with reasonable precision a rough S-shaped curve. This evidence of concomitant variation (due to individual differences in sensitivity or resistance, amount of water intake, dietary and culinary habits, climatological influences) is in accord with general findings respecting the ogival (cumulative frequency graph form) relation between dosage and effect.

[EDITORIAL COMMENT: The index described does not take into account the improved appearance of teeth resulting from the ingestion of water containing optimum concentrations of fluoride. This has been recognized increasingly since the early investigations of the relation of fluoride-bearing waters and the incidence of dental caries, and is well stated by J. R. Forrest ("Caries Incidence and Enamel Defects in Areas with Different Levels of Fluoride in the Drinking Water," British Dental Journal 100:195-200, 1956): "The appearance of the teeth was striking and can be described as excellent. They were well-formed and of particularly good color and structure in contrast to those in the nonfluoride areas which frequently showed evidence of poor calcification." (See also Abstract No. 102.)]

91. Dean, H. T. (National Institute of Health): EPIDEMIOLOGICAL STUDIES IN THE UNITED STATES. In: Moulton, F. R., Editor: Dental Caries and Fluorine. Washington, D. C., American Association for the Advancement of Science, 1946, pp. 5-31.

SUMMARY: In extensive investigations in regions of fluoride-bearing and fluoride-free waters, all other factors that might affect dental caries incidence, except the fluoride content of the drinking water could be excluded, and the optimal concentration of fluoride of about 1 ppm for effective caries prevention with absence of mottling of the teeth was established. The addition of fluoride to waters deficient in this ion was first suggested.

In reviewing the early history of the fluorine-dental caries hypothesis, the speculations reported in the last quarter of the 19th century are mentioned (these are described in more detail in Dean's publication "Domestic Water and Dental Caries," Journal of the American Water Works Association 35:1161-83, 1943; Erhardt: "Kali fluoratum zur Erhaltung der Zähne (Potassium Fluoride for the Preservation of Teeth)," Memorabilien. Monatshefte für rationelle Aerzte 19:359-60, 1874; J. Crichton-Browne: "An Address on Tooth Culture," Lancet 2:6-10, 1892, and others), and the observations by Black, McKay, and others in the United States, in Japan and in Argentina, of a resistance to dental caries as shown by mottled teeth, are discussed.

In 1938, Dean had reported an inverse variation between endemic dental fluorosis and dental caries prevalence as observed on a selected sample of 236 children, 9 years old, of 6 cities exposed continuously to waters of different fluoride content. A higher percentage of caries-free children was found in communities where the domestic water had a fluoride content of 1.7 to 2.5 ppm than in those where it was 0.6 to 1.5 ppm; this was found whether or not the child's teeth showed obvious evidence of mottled enamel. This initial study was followed by others: on 8,148 children in South Dakota, 4,945 in Wisconsin, 400 children with continuous residence from birth in Illinois, culminating in a study of 7,257 children in 21 cities, including Lactobacillus acidophilus studies. In these investigations, the plan of study included consideration of factors known to affect caries incidence: age, sex, color of children; carbohydrate intake; also of those that had been suggested as influencing caries attack, such as latitude and sunlight; the various chemical constituents of the water supplies in addition to fluoride and hardness of water (most of the higher fluoride waters are in the "hard" water group, and most of the low-fluoride or fluoride-free waters are in the "soft" water group). The computation of the dental caries index and the procedure used for clinical examination were defined. The observations included proximal, or smooth, surface caries; loss of first permanent molars; the relation to mottled enamel, and intensity of caries attack.

In examining the factors suggested to affect caries incidence, i. e., the amount of sunshine, diet and water hardness, no relationship was found. In connection with hardness of water, Middletown and Zanesville, Ohio, with relatively hard water (329 and 291 ppm, respectively) and almost free of fluoride, showed high caries rates of 703 and 733; Colorado Springs, however, with unusually "soft" water (27 ppm), and a relatively high fluoride content of 2.6 ppm, showed very low caries rate, 246 per 100 children examined. All data, when subjected to quantitative inductive inspection, checked with respect to other associations, showed that fluoride in the range of 0 to 1 ppm constituted an indispensable condition of dental caries prevalence. As the fluoride content of water approached or exceeded 1 ppm, surprising differences in the amount of dental caries, both in respect to the percentage incidence of affection (child-unit basis) and to the dental caries experience, in the permanent teeth were found. In a table summarizing the findings, the following data were shown: In 3 cities with fluoride waters exceeding 1.4 ppm, there were 0.31 to 0.60 caries per 100 surfaces; in 4 cities with 1 to 1.4 ppm fluoride, 0.59 to 1.3; in 3 cities with 0.5 to 0.9 ppm, 0.47 (Pueblo, Colo.), then 1.4 and 4.1 (Kewanee and Elgin, Ill.); and in 11 cities with less than 0.5 ppm, 3.2 to 18.1 caries per 100 surfaces. Outstanding differences were seen in the amount of caries in the proximal surfaces of the 4 upper permanent incisors: as much as 15 to 20 times fewer in populations using water containing 1 ppm or more fluoride than in those using fluoride-free waters. The first permanent molar mortality rate in populations of children living where the fluoride content of water supplies was less than 0. 5 ppm was about 4 times as high as in the children using water containing more than 0. 5 ppm fluoride.

In discussing the findings, Dean pointed out that there would be little, if any, advantage to be gained in further caries reduction by using a water higher in fluoride content than about 1 ppm. As this concentration is sufficiently low to eliminate the problem of dental fluorosis, the advisability of the addition of fluoride to fluoride-deficient domestic waters was suggested for the control of dental caries. Because of its unusually high prevalence, dental caries seems particularly suited for control through a communal water supply, at low per capita cost. The necessary concentration of fluoride is apparently harmless. Bringing the fluoride content of a domestic water up to 1 ppm does not involve adding anything new to waters not already present in water supplies now being used by several million people in this country; also, the concentration is considerably lower than many hundreds of thousands of these people are now using.

Dean recognized that much investigative work would need to be done before a recommendation could be given for general application: "Before attempting to convert this observed natural phenomenon into one of general usefulness, specifically planned, epidemiological studies should clearly demonstrate the safety of low fluoridation as it might relate to other aspects of the community's general health." The initiation of controlled fluoridation to about 1 ppm of the water supply of one of 2 cities of 40,000 to 50,000 population range, the other serving as control, was suggested. (A footnote states that since the presentation of this paper in 1944, fluoridation of the public water supply had been instituted at Grand Rapids, Mich., Newburgh, N. Y., Brantford, Ont., Midland, Mich., and Sheboygan, Wis.). Should this experiment prove successful, domestic waters from the standpoint of fluoride in relation to dental health may then be classified as optimal (about 1 ppm), excessive (requiring removal of the excess), and deficient (to which fluoride might be added).

[ABSTRACTOR'S NOTE: The following detailed reports describe the investigations discussed: Dean, H. T.: "Endemic Fluorosis and Its Relation to Dental Caries," Public Health Reports (U. S.) 53:1443-52, 1938; Dean, H. T., Jay, P., Arnold, F. A., Jr., McClure, F. J., and Elvove, E.: "Domestic Water and Dental Caries, Including Certain Epidemiological Aspects of Oral L. acidophilus," Public Health Reports (U. S.) 54:862-88, 1939; Dean, H. T., Jay, P., Arnold, F. A., Jr., and Elvove, E.: "Domestic Water and Dental Caries. II. A Study of 2, 832 White Children, Aged 12 to 14 Years, of 8 Suburban Chicago Communities, Including Lactobacillus acidophilus Studies of 1, 761 Children," Public Health Reports (U. S.) 56:761-92, 1941; Dean, H. T., Arnold, F. A., Jr., and Elvove, E.: "Domestic Water and Dental Caries. V. Additional Studies of the Relation of Fluoride Domestic Waters to Dental Caries Experience in 4, 425 White Children, Aged 12 to 14 Years, of 13 Cities in 4 States," Public Health Reports (U. S.) 57: 1155-79, 1942.]

92. Deatherage, C. F. (Illinois State Department of Public Health): FLUORIDE DOMESTIC WATERS AND DENTAL CARIES EXPERIENCE IN 2026 WHITE ILLINOIS SELECTIVE SERVICE MEN. Journal of Dental Research 22:129-37 (April), 1943.

SUMMARY: Selectees from fluoride areas had a lesser incidence of caries, fewer of them required bridges or dentures, and fewer were rejected for military duty.

In an earlier investigation of the dental caries experience of 9- to 12-year-old children and 21- to 28-year-old selectees of Illinois, * the author found that those exposed to domestic waters containing fluoride at 1 ppm or more during the first 8 years of their lives as well as those so exposed during their entire lives had a lower caries experience and a higher frequency of teeth with no caries than those exposed to water containing less than 0. 5 ppm fluoride.

A further study was made of 2, 026 white selectees living in 91 Illinois communities and grouped into 3 categories: fluoride-free (0. 0 to 0. 1 ppm; average age, 23. 9 years); suboptimal fluoride (0. 5 to 0. 9 ppm; average age 25. 7 years); and fluoride (1 ppm and over; average age 25. 3 years). They were then classified according to whether they had used this water during the entire life or during the first 8 years of life only.

The total dental caries rate of men who had been exposed throughout life to water of 0. 5- to 0. 9-ppm-fluoride content was 788 compared with 1,079 for selectees who had lived in fluoride-free areas, and those who had been so exposed to 1 ppm or more fluoride had total caries rate of 621. In comparing total caries rates of selectees who had lived only the first 8 years of their life in fluoride areas with those in fluoride-free areas, the 0. 5- to 0. 9-ppm-fluoride group showed a rate of 887, and the 1-ppm or more fluoride group, 728, as compared with 995 in the fluoride-free communities.

In the fluoride-free areas greater percentages of prostheses (bridges or dentures) were found, and they involved the loss of a greater number of teeth. The percentages of rejection for military service were also higher in these areas.

In another publication, ** the author compared the caries experience of selectees who had lived in fluoride-free areas (0. 0 to 0. 1 ppm) all their lives, with those who had lived in fluoride areas (1 ppm and over) after the eighth year of age. Those who had lived in fluoride areas following the period of calcification of permanent teeth had an untreated dental caries rate of 33 less; filled rate of 161 less; extractions indicated rate of 18 less; missing rate of 30 less; and no caries experience of 241 more than those living in fluoride-free areas. Total caries rate was 838 compared with 1, 079 for selectees in fluoride-free regions. Again, the greater number and extent of prostheses, as well as rejections for military duty, were also in the fluoride-free areas.

The rates reported in both investigations were computed on a tooth population of 28 teeth, excluding third molars.

*Deatherage, C. F.: "Mottled Enamel from the Standpoint of the Public Health Dentist (Including the Relation of Fluorine to Dental Caries in Illinois)," Abstract No. 1;.
**Deatherage, C. F.: "A Study of Fluoride Domestic Waters and Dental Caries Experience in 263 White Illinois Selective Servicemen Living in Fluoride Areas Following the Period of Calcification of the Permanent Teeth," Journal of Dental Research 22:173-80, 1943.

93. Russell, A. L. (South Dakota State Department of Health, Pierre): DENTAL EFFECTS OF EXPOSURE TO FLUORIDE-BEARING DAKOTA SANDSTONE WATERS AT VARIOUS AGES AND FOR VARIOUS LENGTHS OF TIME. I. STATUS OF THE PERMANENT TEETH OF 339 CHILDREN AGED 11 TO 15 YEARS WHO USED SUCH WATER FOR EIGHTEEN MONTHS PRIOR TO ERUPTION OF THE FIRST PERMANENT MOLARS. II. PATTERNS OF DENTAL CARIES INHIBITION AS RELATED TO EXPOSURE SPAN, TO ELAPSED TIME SINCE EXPOSURE, AND TO PERIODS OF CALCIFICATION AND ERUPTION. Journal of Dental Research 28: 298-309 (June); 600-12 (Dec.), 1949.

SUMMARY: Inhibition of dental caries obtained from the ingestion of fluoride during the years of calcification and eruption of the permanent teeth will persist only if exposure to fluoride is renewed periodically or continuously after the eruption of permanent teeth.

Mitchell, a community of approximately 11,000 people, is situated near the center of the so-called "artesian basin" of South Dakota. Prior to 1930, Mitchell obtained its water from a number of artesian wells high in sulfate and with a fluoride content of 2 to 3 ppm. In August, 1930, the city began using impounded surface water containing fluoride at 0.2 ppm.

In 1935, a drought necessitated the intermittent use for 18 months of artesian wells, so that the probable mean concentration of fluoride was 1.15 ppm over this period.

From November, 1947, through March, 1948, 2,140 white children aged from 5 to 22 years were examined, using mouth mirror and explorer. Of special interest were 339 children, 11 to 15 years old, who had been exposed to this increased fluoride prior to the eruption of their first permanent molars. About 10% of the girls and about 5% of the boys showed very mild or mild dental fluorosis. However, no inhibition of dental caries could be demonstrated in this group on the basis of prevalence in younger children of the community, or those of the same age in other fluoride-deficient communities in South Dakota or Hagerstown, Md.

Part II deals with 297 migrant children, aged 5 to 18, who had lived in the surrounding South Dakota artesian basin and had used water with a fluoride concentration of 1 ppm or more for at least one year.

In summary, the findings were: children with exposure to fluoride wholly prior to eruption of the first permanent molars showed a transient inhibition of dental caries in those teeth, which persisted through the age of 10 years, but this inhibition was virtually lost by the age of 14 to 16 years. Caries-inhibitory effects persisted, undiminished in magnitude, through the age of 14 to 16 years in those children whose exposure to fluoride continued past the time of eruption of the first permanent molars.

In children 13 to 17 years of age, whose exposure to fluoride began at birth, tooth types with exposure to fluoride only through the period of calcification presented a slight and perhaps illusory inhibition of caries. Caries reduction in teeth highly susceptible to caries was marked only when exposure to fluoride was continued for some time after eruption of those teeth.

The following hypothesis is suggested: Fluoride may be incorporated into tooth enamel either during the process of calcification or after eruption and when so incorporated is effective in the inhibition of dental caries. This inhibitory effect tends to persist so long as exposure to fluoride is continued but tends slowly to be lost after exposure to fluoride is discontinued, particularly in teeth highly susceptible to caries; hence periodic or continuous renewal of the fluoride content of tooth enamel is required for maintenance of the maximum caries-inhibitory effect.

94. American Dental Association: FLUORIDATION IN THE PREVENTION OF DENTAL CARIES. A Manual Prepared by the Council on Dental Health, American Dental Association, July 1951, 28 pp.

This manual discusses and reviews the following phases: endemic dental fluorosis, mechanism of fluoride action, fluoride content of teeth, fluoride effect on lactobacillus counts, fluoride intake in water and food, fluoride metabolism, toxicity of fluoride, fluoridation in cities with several water sources, sodium fluoride specifications, optimum fluoride concentrations, technical control of fluoride concentrations, and other phases of operational problems, resolutions on fluoridation, cost of fluoridation, and the present results of fluoridation projects.

95. Russell, A. L., and Elvove, E. (National Institute of Dental Research): DOMESTIC WATER AND DENTAL CARIES. VII. A STUDY OF THE FLUORIDE-DENTAL CARIES RELATIONSHIP IN AN ADULT POPULATION. Public Health Reports (U. S.) 66:1389-401 (Oct. 26), 1951.

SUMMARY: Evidence of the persistence of caries-preventive action of fluoride-bearing water into adulthood is given.

Objective lists of natives 20 to 44 years old with verified histories of residence and water usage were prepared in Boulder, Colo. (155 persons examined), where the communal water is virtually fluoride-free (0.1 ppm or less), and in Colorado Springs, Colo. (385 examined), where the communal water has a fluoride content of about 2.5 ppm. Both cities are otherwise similar geographically and as to climate, and the 2 groups are comparable in race and occupation. Persons on the lists were given dental examinations with mouth mirror and explorer.

The prevalence of fluorosis was uniform through the age range at Colorado Springs. No fluorosis was seen in natives of Boulder, while 322 of the Colorado Springs group showed very mild to severe fluorosis. Although the rates of decayed, missing, and filled teeth (DMF) in both groups showed an increase with age, total DMF rates were about 60% lower in Colorado Springs than in Boulder for each age group. These rates were not disturbed by differences in sex, education, or economic status. The phenomenon of caries inhibition continued undiminished through the age of 44 years. Compared with Colorado Springs, Boulder natives had lost 3 or 4 times as many teeth from dental caries, appreciably but not significantly more from periodontal disease, and slightly and insignificantly fewer from other causes. The observed caries-inhibitory effect was essentially similar in pattern and in magnitude to that seen in children native to fluoride areas.

96. Galagan, D. J., and Lamson, G. G., Jr. (U. S. Public Health Service Region X, San Francisco): CLIMATE AND ENDEMIC DENTAL FLUOROSIS. Public Health Reports (U. S.) 68:497-508 (May), 1953.

SUMMARY: Comparison of the fluoride content of municipal waters and of the community fluorosis index in regions of hot climate with those in regions of temperate climate revealed a higher intensity of dental fluorosis in the first, suggesting greater ingestion of water in regions with high mean temperatures. Therefore, the fluoride concentration should be adjusted to climatic conditions.

The prevalence and severity of endemic dental fluorosis in 726 children residing continuously from birth through their 9th year in 6 Arizona communities were studied. The cities (Yuma, fluoride content of water, 0. 4 ppm, Tempe, 0. 5, Tucson, 0. 7, Chandler, 0. 8, Casa Grande, 1. 0, and Florence, 1. 2 ppm) are in a desert area, with mean annual temperatures of approximately 70° F., mean relative humidities of about 37%, 80 to 85% of possible sunshine, and extremely high daytime temperatures. Concentrations of fluoride above 0. 8 ppm resulted in objectionable dental fluorosis; concentrations of 0. 6 to 0. 8 ppm, in an occasional diagnosis of fluorosis, and concentrations below 0. 6 ppm did not cause objectionable fluorosis. Comparisons of the fluoride content of the waters and the fluorosis indices for the Arizona communities with those obtained from selected midwestern communities (mean annual temperature 50°F.) indicate that fluorosis occurs at about twice the intensity in that section of Arizona as it does in the midwestern area with comparable fluoride concentrations, but markedly different climatic factors.

Variation in temperature, radiant heat gain and relative humidity are discussed as possible influential factors in the observed differences in endemic fluorosis between the two areas. The nonclimatic variables pointed out include the possibility of increased fluoride content of soil from irrigation. Increased fluoride intake through use of food products grown on such land seems, however, extremely unlikely. Since generally the children included in the Arizona group were of Spanish descent (83%), an increase in dietary fluoride intake from their staple food, beans, usually prepared by boiling for rather long periods of time, does constitute a factor to be considered.

The comparison of the fluoride concentrations of municipal waters and of the fluorosis indices suggests that Arizona children drink more water than children living in more temperate climates. As a result, there is increased ingestion of fluoride in relation to the concentration found in the water supply.

[ABSTRACTOR'S NOTE: In "Climate and Controlled Fluoridation," Journal of the American Dental Association 47: 159-70 (Aug.), 1953, by using the fluorosis index and the dental caries experience, or index, of the Arizona children and of children in midwestern communities, Galagan concluded that children born and raised in areas with mean annual temperature of 70° F. consume approximately twice as much water as children living in areas with mean annual temperature of 50° F. It is suggested that temperature is the most important element of climatic environment, and that mean annual temperature is the most practical measurement of climatic conditions available at the present time. The fluoride concentration should be adjusted to climatic conditions (see Abstract No. 126). One to 1. 2 ppm of fluoride may be considered optimum in zones comparable to the Great Lakes area, whereas 0. 6 ppm may be considered equally effective in areas similar to Southern Arizona.

In a subsequent study by D. J. Galagan, J. R. Vermillion, G. A. Nevitt, Z. M. Stadt, and R. E. Dart, "Climate and Fluid Intake," Public Health Reports (U. S.) 72:484-90, 1957, records of fluid intake were obtained for 316 Antioch and 139 Brentwood, Calif., children from infancy through 10 years of age, in a series of 39 five-day study periods in a period of about 1 year. Both communities have summer temperatures above 90° F. each summer, and both have mild winters, but there is enough difference between the winter and summer months to permit evaluation of seasonal change. Detailed temperature and humidity figures were obtained.

The most important conclusions were that fluid intake per pound of body weight was highest among infants and decreased with age, and that water intake increased directly with increase in temperature. (E. g., mean daily intake of all fluids for less than 1-year-olds (Antioch), 1. 77 and 1. 67 ounces (oz.) per day per pound of body weight of boys and girls, respectively, and of water, 0. 39 and 0. 53 oz., respectively; of all fluids for 9- to 10-year-olds, 0. 64 oz., and of water, 0. 33 oz. per pound of body weight daily. As the mean maximum temperature increased from the 50°'s to the 90°'s, the mean daily water intake increased from 0.20-0.38 oz. to 0.58-0.62 oz. per pound of body weight.) The decrease of fluid and water per pound of body weight with age results mainly from the increase in body weight with age, not from an actual decrease in the total amount of fluid consumed. It was not possible to determine whether humidity had some additional effect on fluid consumption in areas where high temperature and high humidity occurred simultaneously.]

97. Bushel, A., and Smith, D. J. (New York State Department of Health): NEWBURGH-KINGSTON CARIES FLUORINE STUDY, NO. X. DENTAL FINDINGS FOR 17 YEAR OLD GROUP AFTER NINE YEARS OF FLUORIDE

EXPERIENCE. New York Journal of Dentistry 25:215-8 (June/July), 1955.

SUMMARY: The caries-preventive action of fluoridated water is seen even when children begin ingesting it when their permanent teeth are in the process of erupting or have erupted.

In a recent progress report, a 60% reduction in decayed, missing, and filled teeth (DMF) rates was observed in Newburgh children 6 to 10 years old after 8 years of fluoridation. To determine whether 17-year-olds had derived dental benefit despite the fact that their fluoride experience had not started until age 8, when the crowns of all permanent teeth except the 3rd molar were already fully calcified, a group of 99 Newburgh high school students were examined and compared with 95 Kingston students of the same age.

The Newburgh high school students exhibited approximately 30% less caries experience in permanent teeth than the Kingston students using fluoride-deficient water. Therefore, the observed benefits must have accrued either in the period between calcification and eruption or posteruptively.

98. Gerrie, N. F., and Kehr, F. (Division of Dental Public Health, and Region 8, U. S. Public Health Service, Denver): EXPERIENCE IN PREVENTING DENTAL FLUOROSIS BY USING LOW-FLUORIDE BOTTLED WATER. Public Health Reports (U. S.) 72:183-8 (Feb.), 1957.

SUMMARY: Use of bottled water of low-fluoride content during early childhood in a city with high-fluoride drinking water reduced the incidence of objectional dental fluorosis. A reduction in the fluoride content of the city water would, however, assure optimum fluoride intake as well as prevent the mottled enamel.

In 1953, a study was undertaken in Colorado Springs, Colorado, to learn what success in preventing dental fluorosis had been achieved by the practice of recommending that children be given low-fluoride water during the development of their permanent teeth. For the past 75 years, the water supply of this city has contained fluoride at a concentration of about 2.6 ppm, and the prevalence of dental fluorosis in continuous residents has been high.

Since 1935, bottled water containing 0.2 ppm fluoride has been available from the local dairies. All available 13- and 14-year-old children who were lifetime residents of the city were the study subjects. From information obtained in home interviews with mothers of the children, it was learned that only 56 children had consumed bottled water for as long as the first year of life, as compared with 120 who had consumed only city water. The period of use of bottled water ranged up to 14 years, but only 20% of the 56 children had consumed the bottled water 4 years or longer. Several children were still on bottled water at the age of 14, indicating that their mothers did not understand that it could be discontinued at age 8. Data from dental examinations provided the following observations: (1) Of the children on the city water, 68.3% developed fluorosis. Of those using bottled water for varying periods of time, only 37.5% exhibited fluorosis. The lower percentage in the latter group may be attributed to the use of the bottled water. (2) Many of the children who used the bottled water still demonstrated objectionable fluorosis, probably due to irregular use of this water. The fluorosis index for the group on bottled water was 0.75. (3) About 50% of each group of children were free of dental caries, and there was no substantial difference in the decayed, missing, and filled teeth (DMF) rate between the two groups. This suggests that the children on bottled water received, at a time critical for caries inhibition, enough city water from various sources such as foods cooked in city water, and ingested the latter elsewhere, to produce the same degree of caries immunity as the children on city water.

From these observations, it is concluded that the practice of recommending the use of low-fluoride water has resulted in a reduction in the prevalence of fluorosis and that it has not adversely affected the prevalence of caries. However, defluoridation of the city water supply to 1.0 ppm would seem to be a more effective means of preventing fluorosis. At the same time, it would assure consumption of water containing an optimum level of fluoride for prevention of dental caries by all children in the community.

99. Kroschel, W. P., Hasty, F. E., Jr., DeCamp, F. H., and Sowder, W. T. (U. S. Public Health Service and Florida State Board of Health): NATURAL FLUORIDATION IN JACKSONVILLE, FLORIDA. PREVALENCE OF DENTAL CARIES, TOOTH MORTALITY, AND FLUOROSIS. Journal of the Florida Medical Association 43:895-900 (Mar.), 1957.

SUMMARY: The natural fluoride content of 0.6 to 0.7 ppm in Jacksonville was found to be optimum for the prevention of dental caries and absence of objectionable dental fluorosis.

Dental examinations were conducted on 1,590 white school children, 6 to 17 years old, with a continuous residency in Jacksonville, Florida. The drinking water contains fluoride naturally in a concentration of 0.6 to 0.7 ppm; the annual mean temperature is about 69.4° F. with relative humidities ranging from 87 to 55%.

The data obtained showed caries-free permanent teeth in 44.6% and no missing permanent teeth in 87.6% of the children, while decayed, missing, and filled (DMF) rates ranged from 0.14 teeth at age 6 to 4.26 teeth at age 17. Four cases of "mild" fluorosis (white opaque areas involving at least half of the tooth surface of the second molars, bicuspids, and cuspids) and 119 cases of "very mild" fluorosis (fine white striations involving incisal edges, tips of cusps, and occlusal portions of tooth crowns) were observed, while 182 children were classified as "questionable." There were no cases in which either brown stains, discoloration of enamel, physical enamel defects, or esthetically objectionable appearance of the teeth was observed.

Comparison was made of these findings with the data obtained in similar studies of children from Aurora, Ill., which has water containing fluoride naturally in a concentration of 1.2 ppm, and an annual mean temperature of 48.2° F. with a dry atmosphere showing average summer humidities of 55%.

The conclusion was that the fluoride content in the water of Jacksonville provides protection against dental caries to a degree that appears to be as adequate as that found in communities with higher fluoride concentrations, and that there is no reason to expect more effective caries reduction by increasing the fluoride content of the water. On the other hand, no need is seen to decrease the natural fluoride content of the water, since no objectionable or harmful fluorosis has resulted from its permanent use.

100. Ast, D. B., and Fitzgerald, B. (New York State Department of Health): EFFECTIVENESS OF WATER FLUORIDATION. Journal of the American Dental Association 65:581-7 (Nov.), 1962.

SUMMARY: Among children in the four fluoridation study areas, decayed, missing, and filled (DMF) rates ranged from 48 to 70% lower than in the control cities. Benefits accrued in childhood continue into adult life among those who continue to drink fluoridated water. Evidence indicates there is less malocclusion among children in fluoridated areas than in those in fluoride-deficient areas.

Studies begun in 1945 and 1947 have confirmed the hypothesis, based on Dean's studies, that bringing fluoride-deficient community water supplies to the optimum level would give the same protection against dental caries as was noted where the fluoride was found naturally at the desirable concentration.

These studies are: Newburgh, N. Y., fluoride added to the drinking water since 1945 to bring it to 1.2 ppm, with fluoride-deficient control city Kingston; there study-control relationship has been maintained since the start of the study in 1944 when caries rates for 7- to 14-year-old children of both cities were found to be comparable. Grand Rapids, Mich., and Evanston, Ill., also began fluoridating their water in 1945 and 1947, respectively; however, their control cities were lost by the use of fluoride-bearing water before the studies were completed. In these cities, current data are compared with base-line data and with Aurora, Ill., where water naturally contains fluoride at 1.2 ppm. Brantford, Ontario, began fluoridating in 1945 and its controls, fluoride-deficient Sarnia and naturally fluoridated Stratford, came into the study 3 years later. It is not possible to compare the results of these 4 studies one with another, because of differences in methods of reporting, criteria used, and age groups studied.

However, the general comparison of the 12- to 14-year group, this group being reported in each of the studies over the years (up to 15), shows the following:

	DMF teeth per child	Per cent difference	Missing teeth per child	Per cent difference
Grand Rapids (fluoridated) Ages 12-14				
1944-45	9.58		0.84	
1959	4.26	-55.5	0.29	-65.5
Evanston (fluoridated) Ages 12-14				
1946	9.03		0.19	
1959	4.66	-48.4	0.06	-68.4
Sarnia (fluoride-deficient)				
1959	7.46		0.75	
Brantford (fluoridated)				
1959	3.23	-56.7	0.22	-70.7
Ages 12-14				
Kingston (fluoride-deficient)				
1960	12.46		0.92	
Newburgh (fluoridated)				
1960	3.73	-70.1	0.10	-89.1
Ages 13-14				

In the knowledge that the first permanent molars succumb to caries earliest among the permanent teeth, this criterion was also investigated. In the Newburgh-Kingston study, 92.7% of the Newburgh children examined had not lost any permanent molars compared to 64.8% of the Kingston children (all 13 to 14 years old). None of the Newburgh children had lost more than 2 first molars, while 2.1% of the Kingston children had lost 3, and 2.1% had lost all 4 molars. In Evanston also, while 0.15 molars were lost per 12- to 14-year-old child (1701 children examined) in 1946, in 1959 only 0.04 molars were lost per child of the same age (1060 children examined).

Analysis for differences in caries attack on proximal and occlusal surfaces of posterior permanent teeth of the Newburgh-Kingston children, 10 to 16 years old, showed relatively little difference in 1954-55; in the 6- to 9-year-olds, however, the difference was greater because these Newburgh children had lifetime exposure to fluoridated water, whereas in the older groups the posterior permanent teeth, especially the occlusal surfaces, were well along in development at the time fluoridation was begun.

After 10 years of fluoridation, the rate for children of Newburgh with all of their deciduous cuspids and molars present and caries-free was 5 times greater than in Kingston.

The benefits of fluoridated water ingested during childhood continue into adult life. This was shown in a comparison made by the Public Health Service of adults through age 44 in Colorado Springs, Colo. (fluoride content of drinking water 2.5 ppm), who showed about 60% less dental caries than a similar group residing in Boulder, Colo. (fluoride-deficient); also, Boulder adults had lost 3 to 4 times as many permanent teeth as had those of Colorado Springs (Abstract No. 95).

In order to verify whether the incidence of malocclusion was reduced by the prevention of premature loss of deciduous teeth and of the first permanent molars, maxillary and mandibular casts of 160 Newburgh and 142 Kingston children, 13 and 14 years old, were examined by two qualified orthodontists in 1960. The findings showed that 35. 2% of the Newburgh children had a normal occlusion compared with 12. 7% of the Kingston children. In Evanston also, by comparison with prefluoridation data of 1946, there was 20. 48% less malocclusion among 6- to 8-year-old children who had ingested fluoridated water throughout life, and 17. 03% less in the 12- to 14-year-olds who had used this water for 10 years. In Oak Park, the control city with fluoride-deficient water until 1956, there was an increase of 11. 76% in malocclusion among the 6- to 8-year-olds and one of 7. 84% among the 12- to 14-year-olds in 1956 as compared with 1947.

There is conclusive evidence therefore that ingested waterborne fluoride at the optimum concentration during the years of tooth development will definitely reduce the incidence of dental caries, and will reduce the premature loss of deciduous posterior teeth and of the first permanent molars. As a result of this, there is now reason to believe that the prevalence of malocclusion is also reduced. The benefits accrued during childhood continue into adult life.

[ABSTRACTOR'S NOTE: The detailed and latest reports of these studies are:

Ast, D. B., Smith, D. J., Wachs, B., and Cantwell, K. T.: "Newburgh-Kingston Caries-Fluorine Study. XIV. Combined Clinical and Roentgenographic Dental Findings After Ten Years of Fluoride Experience," Journal of the American Dental Association 52:314-25, 1956. In addition to indicating selective protection by waterborne fluoride of the proximal surfaces of posterior teeth in comparison with occlusal surfaces, the findings include no evidence of any disfiguring mottled enamel nor increased prevalence of gingival and periodontal disease in Newburgh children.

Ast, D. B., Allaway, N., and Draker, H. L.: "Prevalence of Malocclusion, Related to Dental Caries and Lost Permanent Molars, in a Fluoridated and a Fluoride-deficient City," American Journal of Orthodontics 48:106-13, 1962.

Arnold, F. A., Jr., Likins, R. C., Russell, A. L., and Scott, D. B.: "Fifteenth Year of the Grand Rapids Fluoridation Study," Journal of the American Dental Association 65:780-5, 1962.

Blayney, J. R.: "A Report on Thirteen Years of Water Fluoridation in Evanston, Illinois," Journal of the American Dental Association 61:76-9, 1960.

Hill, I. N., Blayney, J. R., and Wolf, W.: "The Evanston Dental Caries Study. XIX. Prevalence of Malocclusion of Children in a Fluoridated and Control Area," Journal of Dental Research 38:782-94, 1959.

Brown, H. K., McLaren, H. R., and Poplove, M.: "Brantford-Sarnia-Stratford Fluoridation Caries Study-1959 Report," Journal of the Canadian Dental Association 26:131-42, 1960.]

101. Chrietzberg, J. E. (Georgia State Department of Public Health): GEORGIA'S WATER FLUORIDATION PROGRAM. Journal of the American Dental Association 65:643-7 (Nov.), 1962.

SUMMARY: The fluoridation program of the Branch of Dental Health is described. Experience has shown that when the concentration of fluoride in water was not brought up to the optimum level in one of the counties, the children did not receive the full dental benefit.

Since 1951, 45 water systems serving 1,074,407 people in 82 communities of Georgia have begun fluoridating, and have continued this program. Eleven referendums were held and won by proponents.

The Branch of Dental Health of the Georgia Department of Public Health prepares a plan every 2 years stating the problems, present status, and objectives for fluoridation. The policy of the Department, established in 1953, requires the community to submit to the Department in duplicate: (1) Resolutions by the local dental society and local medical society or written evidence to show that the majority of the local dentists and physicians approve or endorse fluoridation. (2) A resolution or written evidence to show that the local commissioner of health or the local board of health or both approve or endorse fluoridation. (3) A resolution, ordinance or documentary evidence to show the local governmental authorities' decision to fluoridate. (4) Plans and specifications covering the proposed fluoridation installation including all appurtenant devices, structures, laboratory equipment, storage and handling facilities, with a report describing the fluoride compound to be used and procedures to be followed in controlling the application of the chemical agent. These plans and specifications shall be prepared by a water supply engineer licensed to practice in Georgia and submitted by the owner of the public water supply. In 1960, the specification was added that the average fluoride concentration be maintained at 0. 85 ppm, with a minimum and maximum range of from 0. 7 to 1. 0 ppm.

Before the publication of the policy, lack of knowledge by the waterworks operators that 98% pure sodium fluoride did not constitute 98% available fluoride caused low fluoride concentrations in the water supply for 5 years with the result that the children of DeKalb County did not receive full dental benefit as shown by the first evaluation. By increasing the average concentration by even the small differential of 0. 2 ppm, the improvement seen in the second evaluation of 6-year-old children was increased from 36% in 1957 to 64. 9% in 1962 when the same age groups were compared with the 1952 base line.

As another example of problems brought before the Department, an objection to fluoridation on the basis of the economy and extent of additional reduction in caries that can be expected by bringing the average fluoride content of one community from 0. 38 ppm to 0. 85 ppm, had to be answered. The caries experience was evaluated in 3 communities, one with no fluoride, another with a nearly optimal natural fluoride content of 0. 75 ppm, and the third with 0. 38 ppm. That with 0. 38 ppm was receiving almost half the benefit of the community with 0. 75 ppm, when the latter was compared with the fluoride-free community.

Each community presents a specific problem. These communities are evaluated and local people are organized to promote fluoridation; they determine the proper time to request action and discourage outside interference from both proponents and opponents to fluoridation.

In most instances, particularly in the larger communities, the Branch of Dental Health establishes base-line data of caries incidence when fluoridation is begun for future comparison.

102. Russell, A. L. (National Institute of Dental Research): THE DIFFERENTIAL DIAGNOSIS OF FLUORIDE AND NONFLUORIDE ENAMEL OPACITIES. Public Health Dentistry 21:143-6 (Winter), 1961-62.

Dental enamel, dappled with spots or blotches, or marked with streaks or patches of different color, occurring frequently in essentially fluoride-free and in fluoride areas, may be erroneously attributed to fluoride contained in the water. The causes of these opacities (or hypoplasia, hypocalcification, or hypomaturation) are many; they may be heritable, or associated with abnormal events during gestation or with hemolytic diseases; other causes are still unknown.

The incidence of nonfluoride opacities in communities using water supplies with a fluoride content of less than 0. 2 ppm had been reported by several authors. For example, V. O. Hurme (American Journal of Diseases of Children 77: 61-75, 1949) found them in 83% of children in a New England community; E. R. Zimmermann (Public Health Reports (U. S.) 69:1115-20, 1954), observed them in 36% of children in Montgomery and Prince Georges Counties, Maryland; A. Syrrist (Odontologisk Tidskrift 58:523-8, 1950), found them in 19% of the children in a Norwegian village; G. J. Parfitt (British Dental Journal 98:177-8, 1955), in 50% of the London children examined; J. R. Forrest (British Dental Journal 100:195-200, 1956), in 70% of children in Essex and Surrey; D. B. Ast and his associates (Journal of the American Dental Association 52:314-25, 1956) and G. N. Davies (New Zealand Dental Journal 53:17-21, 1957), in 20% of children living in Kingston, N. Y.

On the other hand, almost all cases of fluorosed enamel (dental fluorosis or mottled enamel) found in communities served with water containing fluoride at levels within public health standards, fall within Dean's classifications of questionable or very mild. Most of them can be detected only by experienced dentists. Dental fluorosis with colored stain and other changes does not occur where water-borne fluoride is present in a concentration of 1 ppm. The general appearance of teeth in a community served by a water supply of such fluoride content has been described as being well-formed, of good color and structure, and more pleasing than in fluoride-deficient communities. This shift is outside the scope of Dean's Index (Abstract No. 90) so that some method, permitting description of this change for the better in quantitative terms, would be useful.

The following characteristics are tabulated for differential diagnosis:

Characteristic	Milder forms of fluorosis	Nonfluoride enamel opacities
Area affected	Usually seen on or near tips of cusps or incisal edges	Usually centered in smooth surface; may affect entire crown
Shape of lesion	Resembles line shading in pencil sketch; lines follow incremental lines in enamel, form irregular caps on cusps	Often round or oval
Demarcation	Shades off imperceptibly into surrounding normal enamel	Clearly differentiated from adjacent normal enamel
Color	Slightly more opaque than normal enamel; "paper-white." Incisal edges, tips of cusps may have frosted appearance. Does not show stain at time of eruption (in these milder degrees, rarely at any time)	Usually pigmented at time of eruption; often creamy-yellow to dark reddish-orange
Teeth affected	Most frequent on teeth which calcify slowly (cuspids, bicuspids, second and third molars). Rare on lower incisors. Usually seen on six or eight homologous teeth. Extremely rare in deciduous teeth.	Any tooth may be affected. Frequent on labial surfaces of lower incisors. May occur singly. Usually one to three teeth affected. Common in deciduous teeth
Gross hypoplasia	None. Pitting of enamel does not occur in the milder forms. Enamel surface has glazed appearance, is smooth to point of explorer.	Absent to severe. Enamel surface may seem etched, be rough to explorer.
Detection	Often invisible under strong light; most easily detected by line of sight tangential to tooth crown.	Seen most easily under strong light on line of sight perpendicular to tooth surface.

103. Russell, A. L. (National Institute of Dental Research): DENTAL FLUOROSIS IN GRAND RAPIDS DURING THE SEVENTEENTH YEAR OF FLUORIDATION. Journal of the American Dental Association 65:608-12 (Nov.), 1962.

SUMMARY: This investigation showed that at a concentration of fluoride of 1 ppm in water, there is a twofold margin of safety against mottling of dental enamel.

In 1961, 822 white and Negro students in the 7th, 8th, and 9th grades (12 to 14 years old) in Central High School of Grand Rapids, Mich. (fluoridating since 1945), were surveyed for dental fluorosis by an examiner with no other concern than the detection of this anomaly, in case its incidence had been overlooked in earlier dental examinations emphasizing the incidence of the carious lesion. All children had been born in the city and had resided there for the first 7 years with absences no longer than 60 days.

Teeth were examined both for dental fluorosis and other, nonfluoride, opacities. Both types were no more prevalent than in Maryland children who had always used a low-fluoride (0 to 0.2 ppm) water. Dental fluorosis findings in white children were, however, significantly lower than those reported in Aurora where the same criteria and methods were used in 1939 and 1953. This may be due to the rigid control of fluoride content of 1 ppm fluoride (± 0.1 ppm) of the Grand Rapids water supply, while in Aurora the fluoride level had a mean of 1.2 ppm. In the Negro children, while there was no comparison with earlier data, findings were similar to the Aurora surveys of white children. The community fluorosis indices for both groups were 0.15 for white and 0.31 for Negro. Both indices are well inside the range of 0 to 0.40 considered unimportant from the esthetic point of view.

Pigmented enamel blotches due to causes other than fluoride were somewhat less prevalent in children with continuous residence than in children who had spent some part of their lives in some other place.

104. Brown, H. K. (Department of National Health and Welfare, Ottawa, Ont.): THE BRANTFORD-SARNIA-STRATFORD FLUORIDATION CARIES STUDY — 1961 REPORT. Canadian Journal of Public Health 53:401-8 (Oct.), 1962.

SUMMARY: Whether derived from natural deposits or added mechanically, about 1 ppm of waterborne fluoride reduced caries remarkably in 14- and 15-year-old children.

The tooth decay experience of all native, continuously resident children of Brantford, Sarnia and Stratford, at least 14 and not yet 15 years old on June 30, 1961, was compared.

All examinations were done by the same examiner for the sake of uniformity of observation. The results were as follows:

	Sarnia (fluoride-deficient) 575 examined	Brantford (fluoridated to 1.2 ppm for 15-1/2 years) 650 examined	Stratford (fluoride in water 1.6 ppm naturally) 342 examined
% Children with caries-free permanent teeth, and standard, error	1.04±0.423	16.46±1.454	15.50±1.957
Mean missing and irreparable permanent teeth/100 children	81.74±6.276	30.15±2.994	25.44±3.709
Mean decayed, missing, filled (DMF) permanent teeth/child	8.04±0.175	3.90±0.121	3.23±0.149
% Children with caries-free permanent molars	2.09±0.597	18.46±1.522	18.42±2.096
Mean DMF permanent molars/child	3.51±0.040	2.56±0.061	2.21±0.078
% Children with caries-free permanent upper incisors	49.91±2.085	86.92±1.322	89.47±1.660
Mean DMF permanent upper incisors/child	1.23±0.061	0.25±0.029	0.19±0.034

The incidence of mottling was also investigated. There were no cases of unsightly mottling, and most fell into the slight or mild categories. About 5% of the Sarnia group showed enamel opacities resembling mottling; about 16% of Stratford and about 20% of the Brantford groups showed slight to moderate type. No ill effects attributable to fluoride have been observed by the Department or reported either by health authorities or by practicing physicians in Brantford or in Stratford.

105. Englander, H. R., and Wallace, D. A. (University of Illinois, Chicago): AURORA-ROCKFORD, ILLINOIS, STUDY III. EFFECTS OF NATURALLY FLUORIDATED WATER ON DENTAL CARIES IN ADULTS. Public Health Reports (U. S.) 77:887-93 (Oct.), 1962.

SUMMARY: The data obtained in this study provide additional evidence that the low caries experience of children consuming water containing 1 ppm fluoride continuously from birth persists during their adult life.

Dental studies were conducted in 1960-61 on 896 white natives of Aurora, Ill. (fluoride content 1.2 ppm), and a comparable group of 935 persons from Rockford, Ill. (relatively fluoride-free), aged 18 to 59 years; all subjects had at least 10 natural teeth. In the 2 groups, the mean age was 33.6 and 33.1 years, respectively, with 32.5 and 26.7%, respectively, of the subjects being over 40 years old; the number of women was 61 and 63%, respectively. Except for a few weeks' absence in any year, all subjects from Aurora had lived in the area continuously from birth until 18 years of age; persons with a total absence of more than 5 years after the age of 18 were excluded. The residence histories of the Rockford group were similar. Distribution as to socioeconomic status, education, dietary practices, and quality of dental care was similar.

For all ages, there were about 10 decayed, missing, and filled (DMF) teeth and 22 DMF tooth surfaces in natives of Aurora, while those of Rockford had 17 DMF teeth and 43 DMF surfaces. Thus, the dental caries experience of Aurorans was 40% less when evaluated by DMF teeth (from 48% for 20- to 29-year-olds to 31% for those aged 50 to 59) and by the DMF surface index, 49% less (ranging from 62% to 36% in the 2 age groups, respectively).

Thirty-seven persons were caries-free in Aurora while only 1 individual was caries-free in Rockford, and almost 3 times as many persons in Rockford had no caries in their 6 maxillary anterior teeth. Also, about 7 times as many edentulous persons were noted in Rockford as in Aurora, raising the average scores of DMF teeth to a 43% lower caries experience in Aurora.

106. Dunning, J. M.: WATER FLUORIDATION. Chapter 16 in: Principles of Dental Public Health. Cambridge, Mass., Harvard University Press, 1962, pp. 338-77.

The fluoridation of water is reviewed from the points of view of the epidemiology of fluoride intake both in respect to dental fluorosis (mottled enamel), and to the reduction of caries, with dental benefits of fluoridation seen in the endemic and the test areas. The toxicology is considered, as are the engineering and economic aspects, the legal, and finally, the political impact of this public health measure. Discussion of the topical application of fluoride solutions to the teeth is also included.

Dunning's discussion of variations in daily water consumption between individuals, which has long concerned those opposed to fluoridation, brings out well the significance of this procedure. In the author's words, "It is true, of course, that wide variations do occur between individuals, whether for reasons of habit or physiology or both. There are also similar variations in dental caries incidence between individuals both in fluoride and in nonfluoride communities. In this connection it is important to point out that in areas of optimum fluoride concentration (1.0 part per million for the most part) this variability in individual water consumption has produced no signs of fluoride change above the level of minor enamel opacity, even among the heaviest water drinkers. The variability, if anything, has produced incomplete protection against dental caries. This latter phenomenon is to be regretted for the individual patient who is not protected, but is of little consequence to the public health officer, whose chief concern is the average level of disease in the community. If the average level has been markedly reduced, public treatment facilities are then far better able to care for those individuals who do not receive protection to the level of the average."

> [ABSTRACTOR'S NOTE: Discussion of fluoride in relation to dental health is included in the other chapters of the book: in connection with milestones in the history of dental public health; as an example of biostatistics in the incidence of dental caries; uses of the epidemiological method in controlling mass disease; the studies of the social scientists of the opposition to fluoridation; fluoride dentifrices; topical application, and dietary supplements; dental health education in preparing voting populations on water fluoridation, and predictions of the future in dentistry. Concerning the impact of water fluoridation on dental care in an area of high caries incidence, the author says that the young children will experience a drop in need for care "very early in the game." For the adult population, if water fluoridation has had time to reach them, the effect may be an increase in the need for dental care along with an improvement in dental health, for teeth which would otherwise be lost, are now preserved and may require further treatment. "When fluoridation has been in effect for a full generation, all segments of the population should benefit, for the adult portion of the population should then have passed through the partial-denture phase into a phase where very few teeth are being lost."]

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 1, 2, 3, 4, 6, 7, 8, 12, 16, 21, 28, 29, 31, 33, 34, 43, 46, 52, 69 through 87, 110, 112, 119, 120, 130, 137, 147, 153, 154

B. OTHER MEANS OF CONTROLLING DENTAL CARIES WITH FLUORIDE

107. Sognnaes, R. F., Chairman, Arnold, F. A., Jr., Hodge, H. C., and Kline, O. L.: THE PROBLEM OF PROVIDING OPTIMUM FLUORIDE INTAKE FOR PREVENTION OF DENTAL CARIES. A REPORT OF THE COMMITTEE ON DENTAL HEALTH OF THE FOOD AND NUTRITION BOARD, PREPARED BY THE SUBCOMMITTEE ON OPTIMUM FLUORIDE LEVELS. National Academy of Sciences, National Research Council, Publication No. 294, 1953, 15 pp.

A study has been made of the problem of providing an optimum amount of fluoride in the American diet. The increasing magnitude of the caries problem and the inadequacy of conventional preventive methods are stressed. The American diet normally provides less than the optimal caries-preventive amount of fluoride. On the basis of epidemiologic and experimental observations in fluoridated communities, the most reliable vehicle for supplementing the fluoride intake is water. The adjustment of the fluoride content of drinking water to the level of 1 ppm fluoride is in principle and in practice the soundest and most effective approach to caries prevention on a large scale known today.

In considering other vehicles for fluoridation, the age and individual variations in consumption of the various products are first discussed. In addition to the inadequacy of quantitative data on food consumption at various ages, the committee has been able to find almost no evidence, except for water fluoridation, with regard to the effect of fluoride supplementation on caries in man. Hence, discussion of the addition of fluoride to food items other than water must be based on certain assumptions rather than on concrete evidence. In view of this, any other vehicle must be subjected to lengthy experimentation before it could be put to general use.

Among solid common foods as fluoride vehicle, flour is considered first as a feasible one from the standpoint of stability and technology of uniform distribution of fluoride. However, in the United States bread would not be used to a great extent in infancy during the early stage of tooth development. Canned baby food is questioned on the basis of whether the distribution is uniform enough in rural districts which also are least likely to have access to water fluoridation.

Among liquid vehicles, bottled fluoridated water is the only source meriting serious consideration as a fluoride supplement in communities without communal water supply. It is possible, however, that this might be too costly as a water supply, in view of the expense of bottling, distributing, and insuring compliance with sanitary regulations.

Next to bottled water, juices and soups which in themselves contribute valuable nutrients, might be considered. In addition to being low in cost, they are conveniently marketed, stable, and used relatively extensively by various age groups without tending to be consumed in excess.

In considering addition of fluoride to milk, the argument that calcium fluoride would be produced, making the fluoride ion less available, is not an important factor in the concentration of 1 ppm. There would, however, be a lack of uniformity of intake in various parts of the country; also, small farms and dairies in rural districts would have problems in controlling the addition of fluoride to small quantities of milk. Furthermore, the intake during the first year of life would depend on the extent to which the babies are breast fed. As human milk contains only traces of fluoride, 0. 09 ppm, a nursing baby would receive only 0. 045 milligrams (mg.) of fluoride per day; this would suggest the need of additional fluoride through water or baby food.

Among other vehicles given consideration, sugar would not satisfy the requirements as to uniformity of use or self-regulatory control. As to salt, no exact information has been obtained with regard to consumption in various age groups. There are doubts as to whether this vehicle would serve the purpose for infants and young children.

Some experimentation has been done with the administration of fluoride tablets. Even though data are not yet conclusive, this procedure is beneficial and safe when properly controlled. It is emphasized that this means of prescribing fluoride might be safe within a group intimately familiar with the possible hazards of the problem and would not have general application except to selected patients on a prescription basis or in a supervised program.

The topical application of fluoride to teeth is safe only in the hand of expertly trained personnel. The reports on its caries-preventive potentials have not been as favorable or uniform as those on water fluoridation. Compared with the latter, it is relatively expensive and time-consuming. The committee is of the opinion that topical application of fluorides is not a substitute for fluoridation through the drinking water or other potential vehicles which, during tooth development, can provide an optimal internal supplement of approximately 0. 5 to 1 mg. of fluoride per day.

In summary, next to fluoridated communal water supply, the use of bottled fluoridated water at 1 ppm, used for cooking and drinking as the exclusive source of water, is the only supplement which could immediately be put to use on the strength of present evidence in regard to amount of fluoride ingested and caries-preventive effect in man. Other vehicles, liquid or solid, cannot at present be recommended but merit further study with respect to consumption, technique of fluoridation, distribution, and effectiveness.

[ABSTRACTOR'S NOTE: The essential points covered in this report are also discussed in R. F. Sognnaes' article, "Relative Merits of Various Fluoridation Vehicles," in Abstract No. 4.]

108. Knutson, J. W., and Scholz, G. C. (Division of Dental Public Health, U. S. Public Health Service): THE EFFECT OF TOPICALLY APPLIED FLUORIDES ON DENTAL CARIES EXPERIENCE. VII. CONSOLIDATED REPORT OF FINDINGS FOR FOUR STUDY GROUPS, SHOWING REDUCTION IN NEW DECAY BY INDIVIDUAL TOOTH AND BY TOOTH SURFACE, AND FREQUENCY DISTRIBUTION OF NEWLY DECAYED TEETH IN TREATED AND UNTREATED MOUTH HALVES. Public Health Reports (U. S.) 64: 1403-10 (Nov. 11), 1949.

SUMMARY: In four studies on a total of 1, 032 children, a series of 4 topical applications of sodium fluoride to teeth effected a 40% reduction in dental caries.

In a series of four studies, sodium fluoride was applied to the teeth of 1, 032 children as follows: In the first group, teeth in the left side of the mouth were treated, while the teeth in the right side served as controls. In each of the 3 other study groups, about half of the children received treatment on teeth in the left side and the other half, in the right side. One year after the series of applications was begun, the children were reexamined by a dentist who did not know which teeth had been treated.

The results indicate that: (1) A series of 4 topical applications of a 2% solution of sodium fluoride, preceded by dental cleansing, effects a 40% reduction in dental caries incidence; more than 4 applications do not increase the caries-prophylactic effect. (2) The caries-inhibiting value of this application is not appreciably decreased during a 3-year period following treatment. (3) The omission of dental cleansing prior to a series of applications reduces the effectiveness of the treatment by about one-half. (4) Application of a saturated solution of lead fluoride (0. 06%), by the same technique, is not associated with a significant reduction in the incidence of caries. (5) The application of a 2% solution of sodium fluoride, followed immediately by a 5% solution of calcium chloride, does not increase the effect obtained by the use of a solution of sodium fluoride alone. (6) An increase in the time interval between applications in a given series from 1 or 2 a week to 1 each 3 to 6 months decreases the caries-prophylactic effect. (7) A concentration of 1% solution of sodium fluoride appears to be as effective in inhibiting new caries as a 2% solution.

In analyzing the data separately for each tooth type and tooth surface, the overall reduction of 40.3% in newly carious teeth in fluoride-treated as compared with untreated teeth consisted of 42.3% for teeth in upper mouth quadrants and 37.4% for teeth in lower quadrants. Among teeth in upper mouth quadrants, except central incisors and cuspids, the reductions varied from 34.7% for 1st molars to 50.9% for 2nd bicuspids. Among teeth in lower mouth quadrants, except incisors and cuspids, the reductions varied from 22.2% for 1st molars to 52% for 1st bicuspids. The overall reduction in newly carious tooth surfaces in treated as compared with untreated teeth averaged 37.9%: 40.6% in upper mouth quadrants, and 34.1% in the lower. For upper teeth alone, the reduction in new decay on distal surfaces exceeded that on occlusal surfaces (45.1% and 42.4%, respectively), while mesial surface decay was lowered by 41%. Comparison of the distribution of the number of newly carious teeth in treated and untreated mouth halves and a theoretical distribution calculated by applying a 40% reduction to the number of carious teeth observed in each untreated mouth half indicates that the caries prophylactic effect of topical sodium fluoride is remarkably uniform for individual children.

109. Bibby, B. G., and Brudevold, F. (Eastman Dental Dispensary, Rochester, N. Y.): THE EXTERNAL ACTION OF FLUORIDES AND OTHER AGENTS ON THE TEETH IN THE PREVENTION OF DENTAL DECAY. In: Shaw, J. H., Editor: Fluoridation as a Public Health Measure. Washington, D. C., American Association for the Advancement of Science, 1954, pp. 148-78.

The results of topical application of sodium fluoride and other fluorides, as reported by 24 investigators are tabulated. The use and effects of prophylactic cleansing pastes, dentifrices, mouthwashes, lozenges and pills, and use of agents other than fluoride are also discussed. The author's comment on the results of these procedures is as follows: "The evidence seems to indicate in a very definite way that dental caries can be reduced to some extent by making topical applications of relatively concentrated fluoride solutions to clean tooth surfaces. It must be noted that this protection is by no means complete and there is still need for the development of better agents than have so far been demonstrated. To date the efforts to find such an agent have been disappointing, but all possibilities have not yet been explored. Although, theoretically, the beneficial effects of topical fluoride can be achieved by the use of dentifrices, mouthwashes, or lozenges in the home, so far attempts to develop practical and effective procedures have been unsuccessful and at this time are by no means ready for general use." The mechanism of action of fluoride is also reviewed.

110. Niederfrank, E. J.: FACTS FOR EXTENSION AGENTS ABOUT FLUORIDE PROGRAMS FOR IMPROVING DENTAL HEALTH. U. S. Department of Agriculture, Extension Service Circular 492, July, 1954, 10 pp.

Any town, regardless of size, can improve the dental health of its children throughout life by adding fluoride to its water supply. For rural families living in areas without public water systems, the application of fluoride to the teeth offers an effective and inexpensive procedure toward a 40% reduction of new dental decay.

Following a brief review of the effectiveness and safety of waterborne fluoride as experienced in the United States, the reduction of decay realized by the application of fluoride to the teeth of children is discussed.

Any county can have a fluoride application program which, closely integrated with the general health and education program of the county may be set up as follows: (1) Inspection of the child's teeth to determine the need for dental care. (2) Application of a 2% solution of sodium fluoride to the teeth of all children at the ages of 3, 7, 10, and 13 years. (3) Referral of children needing dental care to a dentist and provision for those unable to pay for dental services. (4) Dissemination of information on how the dental health of children can be improved. (5) Follow-up services, including an appraisal and evaluation of the program at periodic intervals.

For the organization of the program, it is recommended that a committee be formed, which would get advice from dentists and local authorities, and request the cooperation of county extension agents. If the county already has a dental public health program, some of the personnel may make fluoride applications; if it has none, and is unable to spare practicing dentists, adequately trained dental hygienists will need to be obtained. One dental hygienist can treat about 2,500 children a year, which is about the number of 3- to 13-year-olds in a county of 35,000 people (7%). The cost varies, but averages for the series of 4 applications for each age about $1.50 for each child treated. This will be about 3 cents a month for each family in a county. Where a program has not yet been established, private dentists will, of course, apply fluoride to teeth; however, a community program carried on through the schools will assure that all children are treated at the right time and at very low cost to the family.

Fluoridation of public water supplies will result in up to 65% less tooth decay throughout life at least cost. The complete cost of installed equipment ranges from about $250.00 to $1,000.00 in the smaller communities; the cost of the fluoride compound, from about 5 to 15 cents a year per person. In organizing a water fluoridation program, the county dental society and health department should be consulted first, in that order. The state health department will, upon substantiation of certain requirements, authorize a community to add fluoride. A committee must then be set up to obtain consent of governing authorities of the community. A suggested resolution on fluoridation for community organizations is appended.

111. Jordan, W. A., Snyder, J. R., Peterson, J. K., and Johnson, R. A. (Minnesota Department of Health, Minneapolis): The ASKOV DENTAL DEMONSTRATION. A TEN-YEAR STUDY OF A COMMUNITY DENTAL HEALTH PROGRAM, 1948-1958. FINAL REPORT. North-West Dentistry 38: 444-65 (Nov.), 1959.

SUMMARY: Topical application of fluoride effected 14 to 33.5% reduction in caries, depending upon age group. Cost averaged $30.82 per child yearly.

A community dental health program including all preschool and school children was conducted from 1948 through 1957/58 in Askov, Minn., population 400, mostly of Danish descent, accustomed to a diet high in pastry and sweets, and showing a high prevalence of dental caries. The village of Hinckley, population 900, with dietary habits similar to those in other communities in Minnesota, served as a control area.

Enrollment in the Askov School was about 300 children, since the school served also the rural area and the neighboring communities Bruno and Kerrick. The initial dental examination in Askov showed the rates of decayed, missing, and filled (DMF) permanent teeth to range from 1.58 in the 6-year-old to 18.65 in the 17-year-old children while the corresponding rates in Hinckley were 0.90 and 11.30.

The dental health program included classroom education for students and parents, topical applications of sodium fluoride or stannous fluoride at 3, 7, 10 or 13 years of age, supervised brushing of teeth in grades 1 through 6 twice a day using an ammoniated dentifrice at the beginning, then for 2 years a penicillin and for 3 years a stannous fluoride dentifrice; toothbrushes and pastes supplied for preschool and high school children, regular dental services with X rays, and Lactobacillus counts in certain cases. Considerable emphasis was put on revising dietary habits and restricting the intake of sweets.

At the end of the program, the groups 3 to 5, 6 to 12, and 13 to 17 years showed caries reductions of 27.6, 33.5, and 14%, respectively, as compared to 1948. In relation to tooth surfaces, the reductions were 29.4, 42.8, and 16%, respectively. Reductions in lost teeth amounted to 76% of the deciduous, none in the 6- to 12-year group, and 50% of the permanent teeth in the 13- to 17-year group. All groups in Askov, except ages 14 and 17 years, showed lower DMF teeth rates than the corresponding groups in Hinckley where caries rates had increased in all age groups. The data also demonstrated that dental caries is not a steady progressive activity but occurs rather spasmodically at different age levels.

The average cost of this program per child, age 3 to 17 years, was calculated to be $30.82 per year. Askov did not have a community water system until at the end of the program; at the time, preparations were in progress to install fluoridation of the water supply to a fluoride level of 1.2 ppm. This measure is expected to reduce caries incidence at least by 60% at a calculated average cost of 54 cents per year.

The study leads to the conclusion that a combination of efforts is essential for good dental health, and it helps to substantiate the fact that the fluoridation of community water supplies is the most effective and economical health measure to reduce dental caries. Where fluoridation is not possible, topical fluoride treatment should be considered.

112. American Dental Association, Council on Dental Therapeutics: PRESCRIBING SUPPLEMENTS OF DIETARY FLUORIDES. Journal of the American Dental Association 56:589-91 (Apr.), 1958.

The advantages of communal water fluoridation as compared to the individual administration of dietary fluoride supplements are discussed, leading to the statement that none of the procedures for individual fluoride administration completely duplicates the situation which exists when the community water supply contains fluoride at the optimum level. It is not certain that the benefits derived from fluoride supplements would be of equal quality to those obtained through residency in a community with fluoridated water, and the cost per child for fluoride supplements is much higher than the pro rata cost of a community fluoridation program.

Admitting that in some cases fluoride supplements for young children are advisable, the Council stresses the necessity to observe the following principles in their use:

Concentrated fluoride preparations should be dispensed only on prescription basis and in cases where the parents may be expected to follow directions carefully; written instructions relating dosage to the age of the child should be included as well as warning statements to store the preparation out of the reach of children; fluoride supplements should be prescribed only when the drinking water contains less than 0.7 ppm fluoride and practical examples of adjusting the prescribed fluoride dosage to the fluoride content in water are given; the supplements should be available throughout the whole period of tooth formation which means at least until the age 8 to 10 years; no more than 264 milligrams (mg.) of sodium fluoride should be dispensed at one time.

The use of bottled water containing 1 ppm fluoride is suggested as most feasible during the first 2 years of life for the preparation of formulas and other food. When the drinking water is substantially devoid of fluoride, the aim is to provide supplements of about 0.5 mg. fluoride per day for children 2 to 3 years of age, and about 1.0 mg. per day beyond 3 years of age.

No evidence is available to the Council that fluoride supplements provide dental benefits in adults.

Tablets containing fluoride in the form of calcium fluoride or bone meal have been classified by the Council in Group D3 (unacceptable) because it is difficult or impossible to provide an accurately controlled level of fluoride for the patient by the administration of these slowly soluble fluoride products.

113. Wrzodek, G.: Ist eine Kariesprophylaxe mit Fluor-Dragées erfolgversprechend? (DOES THE PREVENTION OF CARIES BY MEANS OF FLUORINE TABLETS PROMISE SUCCESS?) Zahnärztliche Mitteilungen 47:1-5 (Apr. 1) 1959. U. S. Department of Commerce, translation No. 59-18893.

SUMMARY: In a school program, about 20% reduction in caries was seen in children who had ingested fluoride tablets for 3 years.

The program of caries prevention with the aid of fluoride, initiated by the government of Hessen, Germany, is described. The fluoride content of all communal water supplies in the state was determined at the State Chemical Experiment Bureau by the zirconium-alizarin method. Out of 5,822 water samples, 98% showed a fluoride content of less than 0.5 milligram (mg.) per liter (0.5 ppm), and the average concentration for the state was calculated to be approximately 0.2 ppm. For technical and economic reasons, fluoridation of water supplies was not considered feasible, and preference was given to the tablet method of fluoride administration. In cooperation with a scientific committee and the State Dental Association, a 3-year program was started in 1952 providing for the daily distribution of tablets containing 2.212 mg. of sodium fluoride (1.0 mg. of fluoride) by the teachers to certain groups of children in grades 1 to 3 (6 to 9 years old), while the other children of each grade served as controls. All children were subjected to annual dental examinations and given free dental treatment.

Data on caries incidence were obtained from 8,381 children of the fluoride-tablet group and 5,335 controls after 3 years of the program, and from 13,585 children of the fluoride group and 4,975 controls after 4 years. In both examinations, the two fluoride groups showed lower decayed, missing and filled teeth (DMF) values than the controls, the caries reduction amounting to 20% and 21.9%. For a complete evaluation of the program, it is intended to continue dental supervision of these children until they leave school. The fact that better results were obtained in children who were started on fluoride at an earlier age suggests the soundness of a plan to start fluoride prophylaxis during pregnancy and in infants. Referring to the objections raised by the opponents to the program, the statement is made that no harmful medical or dental side effects attributable to fluoride ingestion have been observed in the children taking the fluoride tablets.

The conclusion is drawn that fluoride tablets are an effective means of caries prevention in children, but that certain conditions are necessary to render this method effective for the treatment of broad masses of children. A tablet program requires permanent supervision and full cooperation of each child and parent to ensure that the tablets are actually taken during school time as well as during vacations, absence from school, etc. It was observed in this 3-year program, that the administration of the tablets was carried out quite effectively for about 2 years, but that tablet taking evenutally lost its appeal to the children and was often neglected. Considering also the cost of the tablets for the individual as well as the state, fluoridation programs involving fluoride tablets should be designed only for a limited period of time and not as a permanent measure.

114. Arnold, F. A., Jr., McClure, F. J., and White, C. L. (National Institute of Dental Research): SODIUM FLUORIDE TABLETS FOR CHILDREN. Dental Progress 1:8-12 (Oct.), 1960.

SUMMARY: In a carefully supervised program, children who had ingested fluoride tablets for up to 15 years beginning at less than 6 years of age, experienced the same protection against caries as those ingesting waterborne fluoride. However, water fluoridation is a more practical and dependable procedure for communities.

The purpose of this investigation was to compare the caries-preventive effect of fluoride when administered in tablet form in amounts corresponding to that available from water containing 1 ppm fluoride with the results obtained by the use of either naturally or artificially fluoridated water. A total of 221 children of parents who were professional employees of the Public Health Service ingested fluoride tablets containing 2.2 milligrams (mg.) of sodium fluoride (1 mg. fluoride) for 1 to 15 years according to instructions given to parents; about two-thirds of the children were started on the regime before age 3, and almost all before 6 years of age. With a few exceptions, all cooperating families lived in Washington, D. C., when the program was started. Whenever a family moved, the new water supply was analyzed. (The instructions caution that fluoride tablets should not be used where the local water supply contains more than 0.5 ppm fluoride.) All analyses of water and deciduous teeth were done at the National Institute of Dental Research.

Dental examination records of 121 children (of 141 available at the end of the study, after excluding those under 4 and over 15 years of age) were analyzed and compared with data reported from corresponding studies conducted after 10 years of fluoridation or in areas of natural fluoride in water. The decayed, extracted and filled deciduous teeth (def) and decayed, missing, and filled permanent teeth (DMF) values in the teeth of these children were comparable. No dental fluorosis of any cosmetic significance was observed (classified as questionable in 3 and very mild 1 case). The deciduous teeth showed a significantly higher mean fluoride content than those of children from nonfluoride areas; the fluoride values also seemed to increase slightly and proportionally with the length of time the fluoride tablets were taken.

Although this study indicates that fluoride tablets seem to be an effective means of caries control, water fluoridation remains a more practical and dependable procedure for communities. The fluoride tablet regimen requires a follow-up on the fluoride content of the water supply and supervision by health authorities for proper dosage and consistent application; the evaluation of the results might be difficult, since there is no guarantee that the program has been followed properly.

115. Editorial (H. H. Wilkowske): FLUORIDATION OF MILK? Journal of Milk and Food Technology 17:107-8 (Apr.), 1954.

Under normal conditions the average fluoride content of milk is in the range 0. 1 to 0. 2 ppm, which is not significantly increased by fluoridation of the cow's drinking water. The addition of fluoride to milk would be extremely difficult because of variations in the normal fluoride content requiring close supervision. The problem of supervision, probably by the milk sanitarian, would be greatly increased because of the numerous milk sources involved. Testing the fluoride content in water is more rapid and accurate than it is in milk. Milk consumption cannot be assumed to be sufficiently constant among various age groups to be able to decide to what extent milk would need to be fluoridated. The cost of fluoridating milk, passed on to the consumer, would be considerably greater than the cost of water fluoridation. The optional feature would appeal to a relatively small religious minority. From the commercial or regulatory standpoint there does not appear to be any sound basis for thinking that further research would be justified regarding the adding of fluorides to milk.

116. Rusoff, L. L., Konikoff, B. S., Frye, J. B., Jr., Johnston, J. E., and Frye, W. W. (Louisiana State University, Baton Rouge and New Orleans): FLUORIDE ADDITION TO MILK AND ITS EFFECT ON DENTAL CARIES IN SCHOOL CHILDREN. American Journal of Clinical Nutrition 11:94-101 (Aug.), 1962.

SUMMARY: The ingestion of a recommended level of fluoride ion during calcification of teeth and prior to eruption, in this case in milk, demonstrated again its value in increased resistance to dental caries.

Estimating that about half of the people in the United States live in areas not served by community water supplies, the authors wished to explore an alternative to fluoridated water.

Since milk is the food most universally used by pregnant women, infants and children during the period of tooth formation, the effect on dental caries of fluoride added to milk in the school lunch program over an approximate 4-year period was investigated. Also studied was any carry-over effect on dental caries 18 months after treatment was stopped.

The controlled experiment began in 2 neighboring schools in Louisiana in October, 1955, with 171 children 6 through 9 years old with sexes about equally divided (about 20 students per age in each group). In one school, the children were served a half pint of homogenized milk containing 1 milligram (mg.) of fluoride (2. 2 mg. of sodium fluoride). During the vacation periods, the parents of these children prepared the milk by adding 8 drops of a prepared sodium fluoride solution to an 8-ounce glass of milk. Children of the control school were served milk without fluoride. The familial backgrounds of both groups of children were similar in every respect. The children received no special diet nor instructions as to care of teeth, and no topical applications of fluoride to the teeth during the experimental period.

Dental examinations, including X-ray films, by local dentists under the supervision of the project dentist, were made in March, 1956 (6 months after initiation of the experiment), and annually thereafter through March, 1959. The final examination was in December, 1960.

A significant reduction of approximately 70% in caries incidence of teeth that had erupted since the initiation of the experiment (1st and 2nd bicuspids and second molars) was obtained for the treated group (65 children) as compared to the control group (64 children). Eighteen months after cessation of fluoride ingestion, a significant difference of approximately 50% in caries rate was retained in favor of the treated group; also, a significant reduction in the increment of caries in the treated group during this interval indicated a carry-over effect by the fluoridated milk. In addition, there was an indication that fluoridated milk administration appears to be of value in reducing caries rate in newly erupted first molars.

[ABSTRACTOR'S NOTE: In an editorial, "U. S. Public Health Service Recommends Fluoridation of Water Rather Than Milk, " in Milk Industry News No. 14:4 (Dec. 14), 1962, the Dental Health Section believes that the city water supply is the only appropriate source of fluoride for the general public because: no food carrier would so universally reach all children; a food carrier would be considerably more expensive to supervise and check-test; the varying fluoride content of community water supplies would require a bottling plant distributing milk over a wide area to vary the amounts of fluoride in its milk for the different communities depending on the natural fluoride available in each community's water supply; it is difficult to control the effective dosage in a food carrier, for if less or more than a half pint of milk containing the daily optimum of fluoride is drunk, the amount of fluoride the child would get would be less or more than the optimum dosage.]

117. Wespi, H. J. (Women's Clinic, Canton Hospital, Aarau, Switzerland): EXPERIENCES AND PROBLEMS OF FLUORIDATED COOKING SALT IN SWITZERLAND. Archives of Oral Biology, Special Supplement, 6:33-9, 1961.

SUMMARY: Fluoridated salt, suggested about 15 years ago as a means of supplementing the intake of fluoride, particularly in the mountainous regions of Switzerland where fluo-

ridation of water is impossible, is now used extensively in that country. After 4-1/2 years, a 22% reduction in caries was obtained.

Fluoridated salt, containing 200 milligrams (mg.) of sodium fluoride and 10 mg. of potassium iodide per kilogram of salt (or ppm), was introduced in the Canton of Zurich in 1955 as a "food with a prophylactic purpose." By 1960, this salt was sold in 16 of the 25 Swiss cantons and total consumption in that year was 2,741,700 kilograms.

The effectiveness of fluoridated salt in reducing decay in permanent teeth of Zurich children was compared in 1961 by Marthaler, after it had been in use for 4-1/2 years, with the results seen in Grand Rapids after 4-1/2 years of fluoridation of water. The index of decayed, missing, and filled teeth was as follows:

	Age	Before	After	Difference in per cent
Grand Rapids	8	2.95	2.16	-27
	9	3.90	2.48	-36
Zurich	8-9	5.83	4.56	-22

The principal problem lies in the dosage, since for good prevention of caries, supplementation of fluoride should amount to 1 to 1.5 mg. daily and should not exceed 5 to 8 mg. daily for an adult. A survey in Wädenswil of the salt consumption of every household showed a mean of 6 grams of salt consumed by an adult per day with a normal range of 3 to 9 grams, the highest being 16 grams (extreme values were discarded). The mean salt consumption in families of adults only is higher than in families with children; e.g., mean intake daily per person in families of 2 adults is 8.39 grams, while in families with children the mean is from 4.26 to 4.79 grams. By assuming that 80% of the salt remains in the food and is ingested, at maximal salt consumption of 16 grams, the daily fluoride intake would be 2.56 mg. (from the salt only), when the salt contains 200 ppm and 3.84 mg. per day with a 300-ppm salt. Following calculation of daily consumption of salt of fluoride content varying from 100 to 300 ppm, it is concluded that fluoride should be contained at about 200 or 250 ppm to provide an additional intake of about 1 mg. with a mean salt consumption of 6 grams.

The mean fluoride content of a day's food of a 14-year-old boy, which was prepared with commercial fluoridated salt (fluoride at 90 ppm) was 1.21 mg., and that of food prepared with a special salt (180 ppm) was 1.97 milligrams.

It is planned to produce a salt containing fluoride at 5,200 ppm, which can be prescribed as a pharmaceutical product. As 0.1 gram of this salt will contain 0.5 mg. of fluoride, this can be given to newborn babies and small children. By mixing 40 grams of this salt with 1 kilogram of the regular salt, a salt of 200-ppm fluoride will be obtained. Thus, every household can mix its own salt.

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 2, 4, 7, 70, 79, 81, 82, 84, 106, 134, 147, 153

C. EFFECT OF FLUORIDE INGESTION ON OCCLUSION AND ON TISSUE ADJOINING TEETH

118. Russell, A. L., and White, C. L. (National Institute of Dental Research): FLUORIDES AND PERIODONTAL HEALTH. In: Muhler, J. C., and Hine, M. K., Editors: Fluorine and Dental Health. The Pharmacology and Toxicology of Fluorine. Bloomington, Indiana University Press, 1959, pp. 115-27.

SUMMARY: There is no relation between waterborne fluoride and incidence of gingivitis or of other periodontal disease.

Statements relating the incidence of periodontal disease, gingivitis, to the presence of fluoride in water in a concentration of 1 ppm are tested by direct observation.

The few animal studies in this respect gave conflicting results and suggested that factors other than fluoride may have been responsible. Surveys of human populations in fluoride (greatly in excess of 1 ppm in some waters) and nonfluoride areas have failed to reveal any association between use of domestic water containing fluoride and the health of periodontal tissue. Observations in Lordsburg, N. Mex. (fluoride content of water 3.25 ppm) and in the Brantford (1 to 1.2 ppm) — Stratford (1.3 ppm) — Sarnia (fluoride-free) study, as well as the authors' own observations in Newburgh (1 ppm in water since 1945), Colorado Springs (2.5 ppm), Kingston and Boulder (fluoride-free), Cameron (0.4 ppm) and Bartlett (8 ppm), are reviewed. Any adverse effect on gingival or periodontal tissues should have been revealed clearly by one or all of these studies. The proposition that water with a fluoride content as low as 1 ppm increases gingivitis is therefore contrary to facts.

The contention that gingival inflammation inhibits the process of dental caries (or that dental caries inhibition in a fluoride community is due wholly to such a process), at least in that advanced clinical stage where inflammation is gross and caries approaches the point of cavitation, is also not supported by findings such as obtained in Birmingham (negligible fluoride in water) and in Montgomery and Prince Georges Counties (1 ppm), Maryland. According to evidence, the two processes are basically independent of each other.

The only conclusion consistent with data is that the use of domestic water containing fluoride has no effect, for better or worse, on the health of gingival and periodontal tissues.

119. Englander, H. R., de Palma, R., and Kesel, R. G. (University of Illinois, Chicago): THE

AURORA-ROCKFORD, ILL., STUDY I. EFFECTS OF WATER HAVING NATURALLY OCCURRING FLUORIDE ON DENTAL HEALTH OF YOUNG ADULTS. Journal of the American Dental Association 65:614-21 (Nov.), 1962.

SUMMARY: No significant differences in periodontal disease, slightly less prevalence of periodontal pockets, similar oral hygiene indices (debris and calculus), and significantly less caries were found in young adults of Aurora, using water containing fluoride, when compared with those of Rockford using fluoride-deficient water.

The principal purposes of the investigation were to measure the effect of the lifetime consumption of an optimum concentration of naturally occurring fluoride on the periodontal health of young adults; to consider factors of oral hygiene in the evaluation of the conditions; to detect any effects that fluoride might have on the amount of calculus, and to evaluate the caries experience in this group.

The groups of young adults, average age 18.2 years, were comprised of 160 residents of Aurora where the drinking water contains natural fluoride at a concentration of 1.2 ppm, and 120 residents of the same age of Rockford using water with fluoride at about 0.1 ppm. Except for a few weeks during any calendar year, all had lived in their respective cities continually from birth. All were healthy individuals free of chronic or acute disease, with at least 10 natural teeth. The socioeconomic conditions of both cities are similar, with a high level of dental care. Frequency of toothbrushing was also determined and was found to be more frequent by the Rockford subjects.

The relative prevalence and severity of periodontal disease, according to the method developed by Russell, showed a mean score that was slightly lower, but not significant statistically, in the Aurora than in the Rockford group, i.e., 0.31 and 0.44, respectively. Of borderline significance was the difference in the percentage of persons in Rockford with one or more frank periodontal pockets, 10%, compared with 3% in Aurora.

The oral hygiene indices as determined on 113 Aurorans and 120 Rockford natives were very similar for both groups. While there was slightly more oral debris in the Aurorans, the difference was not significant and could be explained by the slightly greater frequency of toothbrushing by the Rockford group (1.2 and 1.6 times daily, respectively).

The mean score for calculus was lower in Aurora (0.26) than in Rockford (0.39), the difference being of borderline significance.

Dental caries were significantly less in the Aurorans: clinically measured there were slightly less than 50% fewer decayed, missing, and filled (DMF) teeth and about 62% DMF surfaces in Aurorans than in Rockford natives. The use of X rays raised the caries scores slightly in both groups, but the relative differences remained the same.

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 7, 81, 100

6. LEGAL ASPECTS OF FLUORIDATION; REGULATORY MEASURES CONCERNING FLUORIDES; PUBLIC HEARINGS

The health aspects of the fluorides, just as those of all other chemicals occurring in water and food, are the concern of the Public Health Service and of the Food and Drug Administration. The standards, regulations and statements issued by them, as applying to fluoridation, are listed here. The standards established for chemicals by the American Water Works Association are included in Section 8.

Since the initiation of fluoridation of public water supplies, numerous suits have been brought to court against municipalities and the legality of the procedure has been questioned. This important aspect, as well as the public hearings concerning the fluorides, are included here.

120. Rhyne, C. S., and Mullin, E. F., Jr.: FLUORIDATION OF MUNICIPAL WATER SUPPLY – A REVIEW OF THE SCIENTIFIC AND LEGAL ASPECTS. Washington, D. C., National Institute of Municipal Law Officers, Report No. 140, 1952, 62 pp.

The historical background of fluoridation and recent studies are reviewed. The cities that are fluoridating their water supplies (as of August, 1952) are tabulated according to states; the information includes the population and the date when the program was begun. Some of the technical aspects are discussed.

The legal actions against cities to prevent fluoridation of water are described. The legality of, and municipal tort liability as a result of fluoridation are treated on the basis of court decisions on similar circumstances. The relationship of fluoridation to the Federal Food, Drug and Cosmetic Act and the statements of general policy or interpretation of fluoridated water and processed foods containing such water as adopted in July 1952 are given. The conclusions are as follows: (1) Fluoridation of public water supplies is an effective, safe, economical, and constitutional public health measure for reducing the incidence of dental caries. (2) Children who consume fluoridated water from birth onward will have as much as two-thirds less caries than children who consume fluoride-free water. (3) Consumption of water containing fluoride in the recommended concentration of approximately 1 part of fluoride per million parts of water will not produce noticeable mottling of the enamel of teeth. (4) The scientific evidence now available indicates that fluoridation to the recommended concentration is thoroughly safe and will have no harmful effects. (5) Fluoridation presents no unusual engineering or technical problems to the trained water works engineer. (6) For the great majority of municipalities the cost of fluoridation is reliably estimated at from 5 to 14 cents per inhabitant per year. (7) Fluoridation is not an unconstitutional invasion of the right of freedom of religion. (8) Fluoridation is a constitutionally permissible exercise of the municipal police power. (9) Fluoridation to the recommended concentration will not create municipal tort liability. (10) Neither fluoridation nor the use of municipally fluoridated water in food manufacturing is precluded by the Federal Food, Drug and Cosmetic Act.

The appendix to this report contains a transcript of the case brought before the City of San Diego (motion for nonsuit was granted); Health and Parks Committee, Syracuse, N. Y., Common Council report; an Act Concerning the Fluoridation of Public Water Supplies, prepared by the Connecticut Legislative Council; and an Alexandria ordinance.

121. Conway, B. J. (American Dental Association): THE LEGALITY OF THE FLUORIDATION PROCEDURE. In: Muhler, J. C., and Hine, M. K., Editors: Fluorine and Dental Health. The Pharmacology and Toxicology of Fluorine. Bloomington, Indiana University Press, 1959, pp. 191-203.

The legal and constitutional criteria supporting fluoridation in court cases are clearly presented under the aspects given below and related to the various arguments by the opponents to this procedure.

The authority of a municipality (in the United States): The governmental police powers of a city, town, and village, which, by definition encompass "actions to protect or promote the safety, health, or welfare of the public . . . (which) . . .will not unreasonably interfere with the exercise of fundamental liberties secured by the federal and state constitutions," are derived from the state in which they are located. Therefore, in each of the cases litigated, the court has found the necessary public health police power in the municipality under the provisions in its charter or in other state laws.

The valid exercise of police power: One of the 3 major limitations of police power, that it may not be used to justify an action not reasonably related to one of the recognized goals of the power, was tested in the Chapman vs. Shreveport case in which the ruling of the lower court was reversed by the Supreme Court of Louisiana; the court held that fluoridation is reasonably related to the protection of public health, the municipality's responsibility for which is not limited to methods for combating contagious or communicable disease, because it is intended to reduce the prevalence of disease among a substantial segment of the community.

The test of whether exercise of state police power in this matter interferes with the 14th Amendment by depriving "any person of life, liberty, or property without due process of law," and with the 1st Amendment by interference with religious beliefs (mass medication), has been met in regard to the latter by the judges' ruling that fluoridation of a water supply does not constitute introduction of a medicine into the water, but is a means of supplying a beneficial mineral lacking in the water supply of some communities; also by the ruling that while freedom of religious belief is guaranteed, the freedom to practice what is dictated by one's religious beliefs is not; that in certain cases, state police power may intervene (i. e., prohibition of polygamy, etc.). In the case of the 14th Amendment, the personal liberties are protected only against state action taken without due process of law, and a legitimate and reasonable exercise of state police power is the fulfillment of due process of law. In cases in which the issue of religious freedom and liberty as promoted by state and federal "bill of rights" is raised, the ruling decisions would uphold the right of the municipality, and the only difference would be the limitation of appeal jurisdiction. The Supreme Court of the U. S. has ruled 4 times in fluoridation cases that no substantial federal question was involved and has refused to review them.

In cases where fluoridation was argued to be the same as food adulteration, violating the Food, Drug and Cosmetic Act, or state pure food, or local pure water laws, thus that it overrides federal and state statutes, the decisions were that there is no evidence that 1 part of fluoride in a million parts of water constitutes adulteration of food within the meaning of the Act, and that fluoridation does not conflict with these laws, having been approved by official ruling by the federal, state, and local health authorities. Arguments that by fluoridation the municipality violates state laws on the practice of dentistry, medicine, and pharmacy, have been disposed of by the court's opinion that it is a public health measure and not a form of medication.

In defining the proprietary powers of municipalities, the provision of water is one of them; once undertaken, the municipality can assert its right to promote public health through this medium. Private water companies, the same as the municipal, must conform to appropriate state and local regulations and be subject to municipal ordinances.

Where efforts to show that fluoridation is not effective or that its safety has not been proved were among the arguments against the right of a municipality to initiate fluoridation, the judges have ruled that there is sufficient competent evidence in the possession of the court of the safety and effectiveness of fluoridation to support the municipal governing authorities' determination to this effect.

The points under discussion are illustrated by cases, the major ones of which are listed.

In summary, it has been shown that the courts of 10 states have held that the fluoridation of public water supplies does not infringe on the constitutional or legal rights of the individual, and under appropriate state enabling authority is a proper exercise of the charter powers of local communities. This unanimity of judicial opinion satisfies every legal and constitutional criterion.

122. Butler, H. W. (Legal Counsel, Michigan State Dental Association): LEGAL ASPECTS OF FLUORIDATING COMMUNITY WATER SUPPLIES. Journal of the American Dental Association 65:653-8 (Nov.), 1962.

SUMMARY: It is now a settled principle of law that a community has the inherent right to fluoridate the public water supply.

Every court of last resort in the country has ruled that the addition of fluoride ion to public water supplies is legal and a proper exercise of governmental power and that it does not constitute an infringement of individual constitutional rights. On four separate occasions when the Supreme Court of the United States has been called upon to review these decisions, it has affirmed the state courts by refusing review. A number of the cases brought to court are listed.

The case for fluoridation is illustrated by several cases typical of the basic objections advanced by the opposition and their treatment by the courts.

1. Community Has Legal Power to Fluoridate Public Water Supplies.

Dagmar Readey vs. St. Louis County Water Co., (1961) Sup. Ct. of Mo., 352 S. W. 2d 622, is an example of the courts' rejection of a limited interpretation of the State statute granting powers to a municipality. The Supreme Court of Missouri held that the statutory provision, "the County . . . are hereby empowered and permitted to make and promulgate such rules, regulations or ordinances as will tend to enhance the public health and prevent the entrance of infectious, contagious, communicable or dangerous diseases into such county . . . ," empowered the St. Louis County Water Company to fluoridate the community water supplies (see Abstractor's Note). In this case also as in Dowell vs. City of Tulsa, 273 P. 2d 859, and others, a difference in the justification of chlorination as against fluoridation was contended. The court concluded that there is little difference between adding a chemical which sterilizes the water and kills the bacteria and adding one that fortifies the teeth against a bacterial process which contributes to dental caries.

In another argument, opponents assume that the addition of fluoride is contrary to the implied contract by the city to provide only wholesome, potable and fresh water. In the case of Krause vs. Cleveland, 106 Ohio St. 599, the court held that no contract exists but even if it did, the addition of fluoride would not breach the duty to provide potable water. A similar case is cited in connection with the addition of chlorine in 1912.

2. Fluoridation of Water Does Not Violate Health Laws of a State.

Illegal practice of medicine or socialized medicine has been the contention of several cases: Chapman vs. City of Shreveport, 255 La. 859, 74 So. 2d 142, Dowell vs. Tulsa, 273 P. 2d 859, and DeAryan vs. Butler (1953) 119 Cal. App. 2d 674, 260 P. 2d 98. It was ruled that fluoridation is not medication in the sense of practice of medicine, nor does it constitute social medicine, but it is merely a recognized public health measure under the municipality's general powers, analogous to the chlorination of water supplies.

The claims that fluoridation violates pure food and drug laws as in Froncek vs. Milwaukee (1955) 269 Wis. 276, 69 N. W. 2d 242, and Readey vs. St. Louis County Water Company, the answer by the courts indicated that these statutes are designed to apply to the producers of beverages and were not in any way intended to curtail the activities of municipalities in fluoridating public water supplies.

3. Fluoridation Does Not Interfere With Individual's Constitutional Rights.

By invoking the federal constitution, opponents have claimed that this is (1) discriminatory action to benefit only a small segment of the population; (2) that dental caries is not so infectious or contagious as to require extraordinary police power; (3) that it invades the individual rights of freedom of religion. These are illustrated in Chapman vs. Shreveport, and DeAryan vs. Butler, as well as earlier cases as to compulsory sterilization in 1927, compulsory vaccination against smallpox in 1904, and a case in 1940 involving excessive sound in disseminating religious belief. The courts hold that (1) the well-being of children is "of greater concern of all people, and any legislation to retard or reduce diseases in their midst cannot and should not be opposed on the ground that it has no reasonable relationship to the general health and welfare"; (2) that it has been adequately shown that dental caries is a sufficient deterrent to general health of individuals to justify fluoridation; (3) that under individual right of religion, the constitution protects the freedom to believe; but that freedom to act, and religious freedom are subordinate to the overriding public interest. In the case of Readey vs. St. Louis County Water Company claiming that fluoridation was compulsory medication, the court held that in this instance there was no showing that the ingestion of fluoride ion was against the tenets of the Christian Science faith, as the Missouri River water already contained fluoride at 0. 5 ppm, and that addition of fluoride to bring it to the optimum could not be assumed as an invasion of anyone's constitutional rights.

(Several other court cases listed, but not further discussed, include that of Wilson vs. City of Council Bluffs, 110 N. W. 2d 569 (1961).)

It is concluded that every argument devised by the opponents has been heard and answered by the courts. In view of the unanimity of the comprehensiveness of judicial opinion, it is unlikely that there will be any decisions in the future adverse to fluoridation of public water supplies.

In an addendum by the Editor, an excerpt from the report accompanying H. R. 10904, Departments of Labor, and Health, Education, and Welfare, and Related Agencies Appropriation Bill, 1963, p. 37, states that National Institute of Dental Research scientists have identified the specific agent causing dental caries, which shows this to be probably a very specific disease of bacterial origin and that it is transmissible.

[ABSTRACTOR'S NOTE: As commented on in the Journal of the American Dental Association 64:124, 1962, by overruling the decision of the Circuit Court, and by judging that St. Louis County does have the constitutional right to fluoridate its water supply by ordinance, the Missouri Supreme Court decision also sets a precedent for similar local governing bodies in the state. While it does not mean that referenda cannot be held, it means that they are not required.

In connection with another case listed in the above article, against Council Bluffs, Iowa, in which the lower court had granted a permanent injunction to 4 citizens, the Iowa Supreme Court in September, 1961, reversed this decision by ruling that the City Council of Council Bluffs did have the power to order fluoridation. Further, on November 14, 1961, the Iowa Supreme Court refused to rehear arguments in this case. The action came as a result of a petition for rehearing filed by an attorney for Council Bluffs' antifluoridationists. Notes on these decisions appeared in the Journal of the American Dental Association 63:699, 1961, and 64:124, 1962.]

123. Anonymous: FLUORIDATION WINS VICTORY IN CHICAGO COURT BATTLE. Journal of the American Dental Association 65: 236 (Aug.), 1962.

Ending a 6-year legal battle concerning water fluoridation in Chicago, the Superior Court of Cook County agreed (in June 1962) with the recommendation of the Master in Chancery, Mayer Goldberg, who filed a detailed report upholding the legality and constitutionality of the fluoridation procedure. The injunction suit claiming that water fluoridation was unconstitutional and dangerous to health had been followed by 51 hearings. In his report, Mr. Goldberg termed some of the points raised by the plaintiffs "trifling minutiae which cannot change the obvious and inevitable conclusion presented by the defendants' experts; namely that there is substantial reduction in tooth decay resulting from fluoridation of the domestic water supply to the optimum standard of one part per million. This conclusion is fortified by plaintiffs' own experts. " The report also stated that "fluoridation may be considered not exactly as medication but as analogous to eating a well-balanced diet. Fluoridation is not medication in the generally accepted sense because it merely adds to the water the same minerals which water naturally contains in many parts of the country. "

124. U. S. Food and Drug Administration: STATEMENTS OF GENERAL POLICY OR INTERPRETATION; FLUORIDATED WATER AND PROCESSED FOODS CONTAINING FLUORIDATED WATER. Federal Register 17:6732 (July 23), 1952.

"Pursuant to section 3 of the Administrative Procedure Act, the following statement of policy is issued: 3. 27. Status of fluoridated water and food prepared with fluoridated water under the Federal Food, Drug, and Cosmetic Act.

"(a) The program for fluoridation of public water supplies recommended by the Federal

Security Agency, through the Public Health Service, contemplates the controlled addition of fluoride at a level optimum for the prevention of dental caries.

"(b) Public water supplies do not ordinarily come under the provisions of the Federal Food, Drug, and Cosmetic Act. Nevertheless, a substantial number of inquiries have been received concerning the status of such water under the provisions of the Act and the status, in interstate commerce, of commercially prepared foods in which fluoridated water has been used.

"(c) The Federal Security Agency will regard water supplies containing fluorine, within the limitations recommended by the Public Health Service, as not actionable under the Federal Food, Drug, and Cosmetic Act. Similarly, commercially prepared foods within the jurisdiction of the Act, in which a fluoridated water supply has been used in the processing operation, will not be regarded as actionable under the Federal law because of the fluorine content of the water so used, unless the process involves a significant concentration of fluorine from the water. In the latter instance the facts with respect to the particular case will be controlling."

125. U. S. Food and Drug Administration: NO CONFLICT BETWEEN FOOD AND DRUG ADMINISTRATION AND THE U. S. PUBLIC HEALTH SERVICE REGARDING FLUORIDATION OF PUBLIC WATER SUPPLIES. State Cooperation Information Letter No. 72, 1952.

The quantity of fluoride recommended for addition to public water supplies takes into account the quantity ingested from water employed in cooking as well as from drinking water. "When commercially processed foods which contain added water as one of the normal ingredients are employed in homes or in public eating places, in place of the same or similar articles of food which might be prepared in the home or in the restaurant, the fluoride intake of the populace should be the same whether the fluoridated water is added in a food factory or added in the home kitchen.

"On this basis, the use of fluoridated water in the manufacture of commercially processed foods should not increase the fluoride intake of persons dependent upon fluoridated public water supplies, nor adversely affect the benefits of the fluoridation program," providing there is no increase in the fluoride content of such food due to concentration from the water, which may occur in some processes.

Therefore, it has not been considered necessary to place "restrictions upon the use of fluoridated water in food processing where such use is not calculated to increase the overall fluoride intake as against the general use of fluoridated water supplies in the household as drinking water for culinary use."

There is no conflict in views, for it is believed that there is reasonable agreement among experts as to the intake of fluoride which the human body can handle without adverse effects. The Food and Drug Administration will "continue to zealously exercise (its) functions of undertaking the prevention of sale or distribution of foods which are in fact unsafe, taking into account all of those facts and circumstances which have a bearing upon the question of safety.

"When substantial portions of the population increase their fluorine intake by the amounts being added to the water supply, the total amount which it may reasonably be expected such people will ingest must be looked at by appropriate consideration of probable fluorine intake from all sources other than from the water supply. Sanity and reasonableness must prevail," and the Food and Drug Administration is prepared to deal with any specific problem on the basis of the peculiar facts of the case.

126. U. S. Public Health Service: DRINKING WATER STANDARDS REVISED 1962. Public Health Publication No. 956. Washington, D. C., Government Printing Office, 1962, 61 pp.

The Standards, as revised, to which drinking water and water supply systems used by carriers and others subject to Federal quarantine regulations (interstate commerce) must conform, became effective April 5, 1962. They supersede those earlier established, and were developed with the assistance of an Advisory Committee. They were first published in the Federal Register 26:6737-40 (July 27), 1961, and their adoption was published in the Federal Register 27:2152-5 (March 6), 1962.

The provision for fluoride (Section 5. 23) is as follows: "When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in Table I. Presence of fluoride in average concentrations greater than 2 times the optimum values in Table I shall constitute grounds for rejection of the supply.

"Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the upper and lower control limits in Table I.

Table I

Annual average of maximum daily air temperatures*	Recommended Control Limits Fluoride concentrations in mg. /1. (ppm)		
	Lower	Optimum	Upper
50. 0-53. 7	0. 9	1. 2	1. 7
53. 8-58. 3	0. 8	1. 1	1. 5
58. 4-63. 8	0. 8	1. 0	1. 3
63. 9-70. 6	0. 7	0. 9	1. 2
70. 7-79. 2	0. 7	0. 8	1. 0
79. 3-90. 5	0. 6	0. 7	0. 8

*Based on temperature data obtained for a minimum of five years

"In addition to the sampling required by paragraph (a)** of this section, fluoridated and defluoridated supplies shall be sampled with sufficient frequency to determine that the desired fluoride concentration is maintained."

The resolution of the American Water Works Association accepting these Standards as minimum standards for all public water supplies is included in the publication. An Appendix states the background used in developing the 1962 Standards. In the case of fluoride, this is the finding of the effectiveness in the prevention of dental caries, of the lack of ill effects at optimum concentrations depending on climatic conditions, and of the knowledge of the concentrations in excess of the optimum, as well as the duration of intake which will produce other effects.

**The general requirement under "a" is that the frequency and manner of sampling shall be determined by the reporting agency (defined as "the respective official State health agencies or their designated representatives") and the certifying authority (defined as the "Surgeon General of the United States Public Health Service or his duly authorized representative").

127. Doty, J. R., and Phair, W. P. (American Dental Association): AN ANALYSIS OF THE DELANEY COMMITTEE REPORT ON THE FLUORIDATION OF DRINKING WATER. Journal of the American Dental Association 45:351-6 (Sept.), 1952.

The analysis of the report by staff members of the Councils on Dental Therapeutics and Dental Health is introduced as follows:

In mid-July, a special committee of the U. S. House of Representatives, known as the Select Committee to Investigate the Use of Chemicals in Foods and Cosmetics, issued a report urging communities to adopt a "conservative attitude" toward the fluoridation of domestic water supplies. The Committee was headed by Rep. James J. Delaney (D., N. Y.). Copies of this report have been distributed widely. Since it appears as an official publication of the 82nd Congress, the report has been interpreted by some individuals as a reversal of the complete endorsements of fluoridation which have been made by health agencies of the federal government. Such is not the case. The report is simply an expression of opinion of its seven members. While vaguely negative in its recommendations, the report itself reiterates the fact that fluoridation has been endorsed and recommended by such federal agencies as the U. S. Public Health Service, and the quasiofficial National Research Council. The recommendations of the report, which also included a separate statement by Rep. A. L. Miller (R., Neb.), for the most part ignore the testimony of government scientists and representatives of such organizations as the American Dental Association, American Medical Association, American Public Health Association, Association of State and Territorial Health Officers and many others. In effect, the report was a deferred minority report on the action of Congress itself which earlier had approved an appropriation of funds for the fluoridation of the public water supplies in the District of Columbia. The fluoridation of the public water supplies in the District of Columbia and surrounding communities, with the approval of the full Congress, was in effect prior to the official release of the report of the Committee. The report makes no recommendation for any legislative action by the federal government.

The analysis brings out that serious defects of the report are due to the failure of the Committee to utilize evaluating procedures that would be acceptable to a scientific group by (1) having witnesses appear during the early stages of the hearings who had not made any studies of significant magnitude dealing with fluorides, some of whom in fact stated that their testimony reported only their personal views. No differentiation was made between the degree of reliability to be attached to the statements of the different witnesses. (2) Reference by some witnesses to investigations and their allegations by misinterpretation or quotations out of context were not verified through testimony by the original investigators. (3) There was failure to utilize an adequate scientific approach, by not obtaining information from chemists to elucidate their question as to a possible difference between fluorides occurring naturally in water and those added in controlled fluoridation; also by expressing vague apprehension of the safety, ignoring the mass of evidence from the fact that millions of people have used fluoride-bearing water throughout their lifetime, even though acknowledging the unqualified endorsements of highly qualified and reputable organizations; by disregarding the magnitude of the health problem of dental caries.

[ABSTRACTOR'S NOTE: The complete reference of the report is: U. S. Congress, House, Select Committee to Investigate the Use of Chemicals in Food Products: "Investigation of the Use of Chemicals in Foods and Cosmetics; Report Pursuant to H. Res. 74, 82d Cong., 1st Sess. Fluoridation of Public Drinking Water." Report No. 2500. Washington, D. C., Government Printing Office, 1952, 10 pp.

The reference of the hearings is: U. S. Congress, House, Select Committee to Investigate the Use of Chemicals in Foods and Cosmetics: "Hearings Before the House Select Committee to Investigate the Use of Chemicals in Foods and Cosmetics. House of Representatives, 82d Congress, 2d Session, Pursuant to H. Res. 74 and H. Res. 447 (Continuing Investigation and Study Begun Under H. Res. 323, 81st Cong., 2d Sess.). Part 3. New York City, Jan. 10, 11, 14, 15, 1952; Washington, Jan. 29, 31, Feb. 13, 19, 21, 26, 28, Mar. 4, 6, 1952." James J. Delaney, Chairman. Washington, D. C., Government Printing Office, 1952, pp. 1055-1803.]

128. American Dental Association: INFORMATION BULLETIN, May 1954, 4 pp.

This bulletin concerns the Wier Bill, H. R. 2341, 1954. The Committee on Interstate and Foreign Commerce of the U. S. House of Representatives had scheduled a public hearing at Washington, D.C., for May 25, 26, and 27, on the bill introduced by Rep. Wier (D., Minn.), of Minneapolis, proposing to prohibit the fluoridation of community water supplies throughout the nation.

The A. D. A. does not believe that "any national group or agency, government or private, has any right to dictate to any local community a decision on a public health measure. . . "; it believes that the Wier Bill is contrary to public interest, and urges dentists to advise congressmen on fluoridation.

The facts and findings of fluoridation research are reviewed, as are the safety and effectiveness, the approval by various national health organizations, as well as the nature of the opposition.

[ABSTRACTOR'S NOTE: The complete reference of the hearings held subsequent to this bill is: U. S. Congress, House, Committee on Interstate and Foreign Commerce: "Fluoridation of Water. Hearings Before the Committee on Interstate and Foreign Commerce, House of Representatives, 83d Congress, 2d Session, on H. Res. 2341, a Bill to Protect the Public Health from the Dangers of Fluorination of Water, May 25, 26, 27, 1954," Charles A. Wolverton, Chairman. Washington, D. C., Government Printing Office, 1954, 491 pp.]

The following abstracts, although located elsewhere, are related to the subject matter of this Section: Nos. 6, 80, 81, 84, 130, 137

7. SOCIOLOGIC AND COMMUNITY ASPECTS OF FLUORIDATION

The continued opposition to fluoridation of communal water supplies as a public health measure has interested the sociologist and psychologist. During the past ten years, a number of articles on this subject have appeared in the literature of the social sciences. In 1961 a series of studies were published, each accompanied by an extensive bibliography. An abstract of the combined report is given below.

Included in this Section are other analyses of the opposition to fluoridation, matters pertaining to community programs, aside from the operational, and opinions of governmental and civic leaders.

129. Paul, B. D., Gamson, W. A., and Kegeles, S. S., Editors (Harvard University, Boston, Mass.): TRIGGER FOR COMMUNITY CONFLICT: THE CASE OF FLUORIDATION. Journal of Social Issues 17, No. 4:1-84, 1961.

B. D. Paul's introduction ("Fluoridation and the Social Scientists: A Review," pp. 1-12) reviews briefly the history and facts substantiating the effectiveness and health safety of fluoridation, and states the need for early preventive measures against dental caries, the inadequacy, and costs of dental care.

In discussing the present opposition to fluoridation, referring as well to opposition to earlier public health measures, the thought is expressed that "opposition to a technically sound measure designed to improve health without altering the balance of economic interests, amounts to something more than a murmur of dissent and invites carefully designed studies intended to augment general knowledge of the social process and to help guide the nation's leaders in the determination of public policy." The 3 main arguments of the opposition to fluoridation are stated and evaluated as follows: (1) Its benefits are uncertain; this is the least effective of the arguments, although tooth decay seems to make little impression on the public. (2) It may have injurious consequences; this is more dramatic as it appeals to emotions, evokes anxiety, and as refutation involves technical information, or depends on negative evidence; e. g., that bone, kidney, and other lesions have not been detected despite search, giving rise to doubt. (3) It violates individual rights; this is considered to be perhaps the strongest argument. The nature of these arguments poses questions of public policy such as the proper role of government, to what extent and under what circumstances public authorities should provide health benefits to citizens where no communicable disease is involved, as well as improving understanding between a dentist and layman, and others. A fluoridation proposal often becomes a focus for intense social conflicts: tensions, having their source in industrialization, growth of big government and business, anxieties of nuclear age are triggered by this seemingly innocent issue. This situation is seen as a series of "'natural' experiments in mass persuasion and community decisions and as an opportunity to promote collaboration between health practitioners and social researchers."

The papers presented are discussed as follows:

A. L. Green's paper ("The Ideology of Antifluoridation Leaders," pp. 13-25) is concerned with local opponents who are earnest and sincere, unlike some nationally prominent opponents who combine passion with a measure of opportunism. On the basis of interviews, Green presents evidence that indignation over presumed violation of personal freedom is more fundamental than the danger of poisoning; that fluoridation is seen as an insidious attack by impersonal social forces bent on usurping the powers and the prerogatives of the common citizens; that the basic cause of this feeling of being victimized, sensed by the active opponents, is the increasing remoteness and impersonality of the sources of power and influence affecting the daily life of the individual.

A. Simmel ("A Signpost for Research on Fluoridation Conflicts: The Concept of Relative Deprivation," pp. 26-36) starts from the hypothesis that people who oppose fluoridation have a sense of deprivation, and marshals statistical evidence to support it. He reasons that persons who feel deprived tend to register their resentment against society by voting against the measure. Paul comments that a study of voters in 2 upstate New York referenda confirmed this pattern among the socially and economically deprived segments of the population.

J. P. Kirscht and A. L. Knutson ("Science and Fluoridation: An Attitude Study," pp. 37-44) found, in testing people's attitude toward science, that 4 out of 5 regarded the world as better off because of science. The antifluoridation group, like the profluoridation, shared a generally positive evaluation of science, although the former were not quite as positive as the latter. Many who valued science, nevertheless felt uneasy about its indirect effects (production of deadlier weapons, weakening of spiritual values); this uncertainty was more characteristic of anti- than of profluoridationists. Although not conclusive, indications are that rejection of the measure tends to correlate with greater ambivalence toward science and its byproducts. Paul comments that it must be borne in mind that features distinguishing pro and anti voters are tendencies and matters of degree, such as is the case of Christian Scientists, or people who devalue science, or feel socially dispossessed or share a "naturalistic attitude syndrome," and predict that they will line up against fluoridation. The search for personality types and categories of persons who tend to vote against fluoridation should not be abandoned, for results of successive votes in the same community have differed widely; this may be attributed to differences in the nature of the campaign and other situational issues.

H. M. Raulet's paper ("The Health Professional and the Fluoridation Issue: A Case of Role Conflict," pp. 45-54) concerns the active proponents from the point of view of role analysis. He observed the progress of 2 campaigns led by dentists, physicians and public health officers who, naive in the ways of power and propaganda, tended to defeat their own purposes. In choosing to spurn the politically partisan role and to emphasize the professional one, they apparently confirmed opponents' charges of being undemocratic and conspiratorial.

I. T. Sanders ("The Stages of a Community Controversy: The Case of Fluoridation," pp. 55-65) develops a scheme for classifying and identifying the temporal stages through which a controversial community issue passes. Certain events, such as the appearance of open opposition or summoning assistance from the outside, typically occur during given stages.

W. A. Gamson and P. H. Irons ("Community Characteristics and Fluoridation Outcome," pp. 66-74) compare and analyze 4 sets of data correlating the results of fluoridation outcome with democratic and other characteristics of the communities involved, such as size (most of the very large cities have instituted the measure in contrast to smallest towns); this may reflect greater tendency of larger communities to bring fluoridation to the point of decision. The association between size and age, education, income, rate of population growth and political affiliation, although showing certain tendencies, is not entirely conclusive.

S. S. Kegeles ("Some Unanswered Questions and Action Implications of Social Research in Fluoridation," pp. 75-81) enumerates some of the gaps in existing knowledge and some studies in progress. In discussing the reports presented, he concludes that they do not yet present any clear answer on how to win a referendum. While future research will probably continue to emphasize understanding rather than action, he believes that help for the practitioner will be one of the eventual by-products.

130. McNeil, D. R.: THE FIGHT FOR FLUORIDATION. New York, Oxford University Press, 1957, 241 pp.

In the preface, the author states that controversies over public health measures, such as licensing of medical practitioners, vaccination, chlorination, and others, have produced some of the most bitterly fought campaigns in the history of American people. This is true also of fluoridation. The effects of the fight over this measure, which is seen as a case study of American democracy, on the social and political equanimity of communities have been far-reaching.

In gathering the story of fluoridation, McNeil personally contacted many of the investigators, such as Dr. Frederick S. McKay, H. Trendley Dean, and others, and drew heavily on their correspondence, news clippings and other papers deposited now with the State Historical Society of Wisconsin and documented in extensive notes to the text. The result is a vivid account first of the discovery of the cause of mottled enamel in Colorado and other western states, of the caries-preventive influence of waters bearing fluoride within certain concentrations, and the subsequent events surrounding the fluoridation movement.

Soon after Dean had established the relationship between fluoride and dental caries, and before the large-scale fluoridation experiments began, Dr. A. H. Finke of Sheboygan, Wisconsin, mentioned (in 1941) the possibility of widespread fluoridation to inhibit dental decay. His talk aroused the enthusiasm of a small group of dentists who, anxious to have the benefits enjoyed by everybody immediately, formed a "Fluorine Study Committee" of the Wisconsin Dental Society in early 1943. This committee was to investigate the chemistry of fluoride and effects of fluoride-bearing water on people residing in these areas, the value of topical application, and the legal aspects of adding fluoride to water. Dr. John G. Frisch became the leader of the group in urging fluoridation of public water supplies; in fact, before the study communities became organized, he began adding fluoride at 1.5 ppm to drinking water for use by his 9-year-old son and 7-year-old daughter. Frisch campaigned hard to have Madison be the first city to adopt fluoridation, but was met with opposition set off by two aldermen. Madison started adding fluoride through one of the city's 10 pumping stations in 1947 and it was not until 1950 and after considerable battle that the entire supply of the city became fluoridated. By that year, 50 communities in Wisconsin had approved the measure through Frisch's activity.

The efforts of Frisch and his group toward endorsement of fluoridation by the American Dental Association and by the U. S. Public Health Service are detailed. This was realized in 1950.

That year also marked the beginning of a concentrated and bitter fight against fluoridation first sparked at Stevens Point, Wisconsin. From this time on, fluoridation became a political issue. The nature of the antifluoridation movement, the reasons why approval of fluoridation was rejected in various cities such as Seattle and others, the Delaney Committee Hearings in 1952 and the hearings on the Wier Bill (H. R. 2341) in 1954 are described in detail.

The book closes by saying that the "antifluoridation 'crusade' was a political protest movement against the scientific organizations and a government which heeded their wishes. Fluoridation became a battle over who should decide the issue, the people or their democratically elected officials, acting on the advice of scientific experts."

131. American Dental Association: FLUORIDATION FACTS. ANSWERS TO CRITICISMS OF FLUORIDATION. Chicago, Ill., July, 1962, 23 pp.

Forty-five typical assertions made by opponents of fluoridation of drinking water supplies are answered concisely on the basis of reliable facts as reported in the literature. The assertions range from allegations pertaining to health, such as that fluoride in the public water supply will harm health, is a poison, causes cancer, unsightly staining of teeth, and hardening of the arteries; does damage to internal organs, is not an essential nutrient, makes bones brittle and weak, aggravates skin acne, may react differently in individuals, blocks calcification when magnesium is low in water supply; is a hazard to waterworks personnel, is not approved unqualifiedly by the American Medical Association, has caused increased number of deaths; will not harden teeth permanently; inhibits enzyme function; also that vital statistics are insufficient to evaluate safety. Other criticisms include: fluorides are by-products of aluminum; fluoridation should be put to a referendum, is still in the experimental stage, benefits children only, does not produce same results as natural fluorides, is not recommended by the American Water Works Association, is a restriction of religious freedom, does not adhere to standards for experimentation on lives of human beings, is mass or compulsory medication or socialized medicine, interferes with industrial processes. Still other assertions are costs and wastefulness of fluoridation; possibility of overdosage, with water works liable; it involves difficult engineering problems; Federal Food and Drug Administration might take action against processors of food. A subject index and bibliography are included.

132. Easlick, K. A. (University of Michigan, Ann Arbor): AN APPRAISAL OF OBJECTIONS TO FLUORIDATION. Journal of the American Dental Association 65:686-93 (Nov.), 1962.

The most frequently encountered objections to fluoridation as determined by a survey of 74 public health dentists are:

1. Fluorine is a well-known poison whose long-term effects are not fully known, and about which there is much disagreement among professional groups.

2. One group of objections, based on the alleged toxicity of fluoridated water, consists of statements of the etiological significance of fluorine in 13 mental and neurological diseases and abnormalities that have been attributed to the ingestion of a trace (1.0 ppm) of the element through drinking.

3. Fluorides added to supplies of water will cause serious damage to the internal organs.

4. Fluorides cause general protoplasmic poisoning.

5. Fluorides are cumulative poisons. Their effects may not be noticed for 20 years or longer.

6. Fluorine ions distort the metabolism of the body and make the individual more susceptible to every known disease.

7. Fluoride, added to the water, may initiate or aggravate disease, particularly if drunk by the aged or persons chronically ill.

8. Fluoridation is mass medication.

9. Fluoridation is an invasion of the personal rights guaranteed by the Constitution and, hence, destroys the individual's freedom of choice.

10. Fluoridation permits a municipality to interfere with the religious freedom of its residents.

11. There are better methods of getting fluorides used and the individual therefore has the right to accept or reject the use of the fluoride.

12. Adjusting a city's supply of water is expensive and wasteful.

13. There is lack of proof of effectiveness.

Each of these objections is appraised on the basis of the literature.

[ABSTRACTOR'S NOTE: The 82-page complete report published in 1960 by the University of Michigan, School of Public Health, Ann Arbor, Michigan, "Classification and Appraisal of Objections to Fluoridation," by K. R. Elwell and K. A. Easlick lists a total of 137 objections and appraisals, grouped under the following broad headings, with detailed subheadings to facilitate the location of specific objections: Toxicity for animals and human beings; interference with commercial activities utilizing water; expense; problems of engineering control; displacing better methods for administering fluoride; interference with human rights; lack of evidence of value; other objections. An extensive bibliography is included.]

133. Jackson, H. R. (Better Business Bureau, New York City): A LAYMAN LOOKS AT FLUORIDATION. Journal of the American Dental Association 57:353-7 (Sept.), 1958.

The author wonders "why an apparently safe and relatively simple and tested technique for meeting what is obviously one of the major needs of all our children — improved dental health — should become a matter of highly charged, emotional public controversy." He mentions the yearly cost in N. Y. of dental care and the fact that less than half of the citizens receive adequate care; also, the fact that dental defects were the largest single cause of rejections among the first 2 million men examined for service during World War II confirms this as a problem of paramount importance involving the health of all people. In his belief, fluoridation is actually one of the least controversial public issues in a long time in light of the overwhelming majority of expert scientific judgment which states the efficacy and safety of the solution of a problem.

Although he does not question the right of any group or individual to speak out, he is concerned about the tampering with truth and misrepresentation of the facts by antifluoridationists. This is illustrated by a number of examples of literature distributed by the opponents. While he deplores the delay in effecting the procedure, he is optimistic that by developing a wide understanding by education of the citizens and acceptance of the true facts of the issues, the ultimate goals will be achieved.

134. Flemming, A. S. (Secretary of Health, Education, and Welfare): FLUORIDATION. I. Public Health Reports (U. S.) 74:511-3 (June), 1959.

The Secretary of Health, Education, and Welfare states that a very significant setback in the progress of fluoridation during the past 2 years had been called to his attention. He finds it difficult to understand why in view of the proved dental health benefits of the measure every community with a public water supply has not availed itself of them. He concludes that this has not been done due basically to the fact that the opponents are a militant minority while the proponents are an unmilitant majority.

The Secretary believes that while some people will continue to oppose fluoridation as a matter of principle, those who succeed in blocking it or who are the most vocal opponents are persons who have been charged by the Food and Drug Administration with making false health claims for nostrums and devices and thereby influencing their customers against seeking needed medical service. Much the same view was expressed by the Secretary and General Manager of the American Medical Association in an Editorial in "Today's Health," June, 1955. The same opposition arose in the chlorination of public water supplies and other measures which were delayed because of it about 50 years. This, the Secretary hopes will not happen in the case of fluoridation.

[ABSTRACTOR'S NOTE: Article 2 (pp. 513-7) in this series is a report on fluoridation in the United States.

Article 3 (pp. 517-20) concerns statements on proposed alternatives to fluoridation of water supplies, such as fluoridated tablets, bottled water, milk, bread, and salt. At present, the value of these is not conclusive. However, if their effectiveness, practicability, and safety of application can be satisfactorily demonstrated, they may become very valuable in regions where water fluoridation is not possible.]

135. Terry, L. L. (Surgeon General, U. S. Public Health Service): THE NEXT GREAT AREAS FOR TEAMWORK IN NATIONAL HEALTH. Journal of the American Dental Association 63:183-9 (Aug.), 1961.

In this presentation before the Twelfth National Dental Health Conference, American Dental Association (ADA), 1961, the author reviews the long-standing partnership between the Public Health Service (PHS) and the medical professions. In the field of dentistry, cooperation has been maintained in the areas of dental research, professional education, and community health services, and it is the policy of the PHS to support projects designed to improve the nation's dental health. Among the latter, emphasis is placed on fluoridation of public water supplies, which was to feature prominently on the Conference program. In discussing the reasons for the rejection of fluoridation in 29 of 35 referenda in 1960, in spite of 10 years' endorsement by the PHS and ADA, the thought is expressed that perhaps the local communities have not been given as much help by the national organizations as they need. The strengthening of services in this field by the PHS is proposed until fluoridation has received the widest possible application.

136. Anonymous: KENNEDY FLAILS EXTREMISTS OPPOSED TO FLUORIDATION. Journal of the American Dental Association 64:123-4 (Jan.), 1962.

This note reports on a speech by President John F. Kennedy on November 18 in Los Angeles, in which the President criticized the "right wing fanatics who, he said, 'sow the seeds of doubt and hate'... and who are unwilling to face up to the danger from without. .. They call for 'a man on horseback' because they do not trust the people."

It is also stated that earlier in 1961, "the President authorized his personal physician, Janet Travell, to issue a statement that he and his family drink the regularly supplied water of Washington, which is fluoridated 'in accordance with the recommendations of the Public Health Service that communities adopt this measure as a means of improving dental health.'"

The following abstracts, located elsewhere, refer to the subject matter of this Section: Nos. 8, 69, 77, 79, 80, 81, 84, 101, 110, 127, 128, 144

8. ADMINISTRATIVE, ENGINEERING AND CHEMICAL ASPECTS OF FLUORIDATION OF PUBLIC WATER SUPPLIES AND OF THE REMOVAL OF FLUORIDE FROM WATER, INCLUDING SURVEYS OF FLUORIDATION

The addition of fluoride to public water supplies has created no unusual problems for the personnel of a waterworks department of a community or for the private supplier of water. Modern water treatment involves the use of many chemicals with suitable equipment, precautions to personnel, and adherence to standards and analytical tests as required by the Public Health Service and by the American Water Works Association.

The references listed here, in addition to discussions of needed equipment and handling of chemicals, include the standards for chemicals established by the American Water Works Association. Reports and surveys of fluoridation are also listed here, as they generally include chemicals used and engineering practices. Publications dealing with effects of fluoridated water on industrial processes, and other practical matters are also treated here.

137. American Water Works Association: THE FLUORIDATION OF PUBLIC WATER SUPPLIES. STATEMENT OF RECOMMENDED POLICY AND PROCEDURE. Journal American Water Works Association 41:575-9 (July), 1949.

The statement, "In communities where a strong public demand has developed and the procedure has the full approval of the local medical and dental societies, and local and state health authorities, and others responsible for the communal health, water departments or companies may properly participate in a program of fluoridation of public water supplies," was presented by A. P. Black, Chairman of Special Committee on A. W. W. A. Policy re Fluoridation of Public Water Supplies, and approved by the Board of Directors on May 29, 1949.

Tentative recommended procedure covers handling of fluoridation requests; responsibility for fluoridation; liability involved; authorization; disposition and items of cost; application of fluoride; and control. The latter involves adherence to specific instructions from the controlling health authority. Samples must be taken from points before and after fluoridation and from one or more points in the distribution system. The method determining the fluoride content of the water shall be in agreement with the latest edition of "Standard Methods for the Examination of Water and Sewage." The results shall be recorded and water samples shall be submitted to the state health authority at stated intervals for control purposes. The tests for the purity of the fluoride chemical used shall have the approval of the state health authority, and shall include the U. S. Pharmacopoeia tests for heavy metals.

[ABSTRACTOR'S NOTE: The above statement was reaffirmed without change by the Board of Directors of the Association on April [illegible], [illegible], and again in June [illegible].]

138. American Water Works Association: AWWA STANDARD FOR FLUOSILICIC ACID. Journal American Water Works Association 53:113-8 (Jan.), 1961.

This standard (first edition approved as "tentative" in 1954, second edition approved 1960) applies to fluosilicic acid (H_2SiF_6) for use in the treatment of municipal and industrial water supplies. Part A contains regulations defining the material and specifying precautionary practices, methods of sampling and testing, impurities, procedure of rejection, and administrative requirements; Part B regulates sampling, inspection, packing and marking; Part C covers the testing methods intended for use with Part A and Part B of this document as well as the following alternative methods for determining the content of fluosilicic acid: the specific gravity method, the hydrogen titration method, and the method for determination of free acid.

139. American Water Works Association. AWWA STANDARD FOR SODIUM SILICOFLUORIDE. Journal American Water Works Association 53:107-12 (Jan.), 1961.

This standard (first edition approved as "tentative" in 1954 second edition approved in 1960) applies to sodium silicofluoride (Na_2SiF_6) for use in the treatment of municipal and industrial water supplies.

Part A, B, and C cover the same categories as outlined in Abstract 138, as applying to sodium silicofluoride.

A note indicates that the list of limitations or impurities as well as tests recommended for them have been omitted because of the high degree of purity (98%) required for sodium silicofluoride by this standard.

140. American Water Works Association: AWWA STANDARD FOR SODIUM FLUORIDE. Journal American Water Works Association 53: 11-6 (Jan.), 1961.

This standard (first edition approved as "tentative" in 1950 second edition approved in 1960) applies to sodium fluoride (NaF) for use in the treatment of municipal and industrial water supplies.

Part A and B cover the same categories as outline in Abstract 138, and Part C contains the testing methods intended for use in connection with the other 2 parts of this document including methods for the determination of fluoride and fluosilicate as well as limitations on impurities in sodium fluoride.

141. Goldstein, S. W. (American Pharmaceutical Association Laboratory): FACTS ABOUT FLUORIDATION. WHAT THE PHARMACIST SHOULD KNOW ABOUT FLUORIDATION OF PUBLIC WATER SUPPLIES. Journal of the American Pharmaceutical Association, Practical Pharmacy Edition 13:323, 352 (May), 1952.

SUMMARY: Fluoride-enriched water supplies can be freely used for all pharmaceutical purposes for which the same waters were satisfactory before their fluoridation.

All questions as to the effect of fluoridation of public water supplies on pharmaceutical compounding can be answered very briefly: There should be no noticeable effect on compounded products. Many pharmacists have, and will continue to use only distilled water, and in some regions must do so because of high iron or sulfide content, or extreme hardness due to calcium or magnesium compounds.

Wherever fluoridation of the water supply is undertaken, the dissolved constituents of water are limited by what is considered to be acceptable by the American Water Works Association. On the basis of the solubility of any fluorides that might be formed, it is improbable that chemical incompatibilities would result from the use of fluoridated water in compounding pharmaceuticals. In order to test theoretical considerations, various products, such as 1% atropine sulfate solution, and others, were prepared to contain sodium fluoride at a concentration of 12 ppm. No change attributable to the added sodium fluoride was noted in any of the products, even though the fluoride was added at greatly higher amounts than encountered in fluoridated water. Solutions of calcium bromide 10% showed no change with concentrations of sodium fluoride up to 6 ppm.

Injectable preparations are not and should never be prepared with ordinary water. Water for injection is prepared by distillation. Solutions of antibiotics are more stable when prepared with sterile distilled water or a sterile buffered vehicle, which is usually supplied with antibiotics to be dispensed in solution or suspension.

[ABSTRACTOR'S NOTE: See also Abstract No. 126 for the limitation of ions and pollutants in drinking waters. In addition to fluoride, these are: chloride, copper, iron, manganese, nitrate, sulfate, zinc, as well as total dissolved solids, alkyl benzene sulfonate (detergent), carbon chloroform extract, cyanide, phenols, and radioactivity.]

142. Weir, W. V. (St. Louis County Water Co., University City, Mo.): CONSIDERATIONS IN SUPPLYING FLUORIDATED WATER TO INDUSTRY. Journal American Water Works Association 45:369-75 (Apr.), 1953.

SUMMARY: No interference with industrial processes has been caused by fluoridated water, except for cracking of artificial ice, now corrected. The fluoride content of processed foods, beverages, and feed has not exceeded the usual ranges found in them.

Very little has appeared about adverse effects of fluoridated water on industrial processes, excepting the cracking of artificial ice, which can be corrected easily.

The arguments advanced by Bratton (Journal American Water Works Association 45:364-8) against fluoridated water in various manufacturing processes are discussed. Weir first points out that many manufacturers have their own water supplies because some may require conditioning far beyond the need for safety of the domestic user, others may have only minor quality requirements. In considering the example of wet grinding of corn, every one of the 12 large mills in the United States has its own supply, although a few draw on public water supplies. Assuming that fluoridated water is used, the final corn gluten feed may exceed 3 ppm fluoride, corn syrup will have no more than 3 to 4 ppm (by assuming that fluoride would concentrate in steep water), and total corn feed, not more than 3 ppm; thus, they will be safely below the limits set by control officials. The fluoride in corn syrup would add only the equivalent of drinking an extra glassful of water. In yeast production, at 1 ppm, fluoride may stimulate yeast metabolism slightly, 25 ppm or more being needed for inhibition. Mention is made of a study (Wisconsin State Health Laboratory) of fluoride accrual in yeast from 2 breweries. Dry yeast produced with water of a fluoride content of 1.6 ppm occurring naturally, contains (dry) 24 ppm fluoride; the beer from this water contains 0.7 ppm. Using 1-ppm-fluoride water, dry yeast contains 20 ppm fluoride. In both instances, the brewery operations were normal.

The State Cooperation Information Letter by the Food and Drug Administration in regard to use of fluoride water is quoted (see Abstract No. 125). As an increasing number of fluoride-bearing foods and beverages will be shipped from community to community, whether the quantities of fluoride in these goods have any real significance must be assessed by the proper health authorities.

143. Gruno, W. N., and Sload, R. Q. (Georgia Institute of Technology, Atlanta): EFFECT OF FLUORIDE CONCENTRATION ON SLUDGE DIGESTION. Sewage and Industrial Wastes 27:1-3 (Jan.), 1955.

SUMMARY: Fluoridated water does not affect the digestion of sludge in the treatment of sewage.

To test the possible effect of the addition of fluoride in the course of fluoridation of water on sludge digestion, almost 5 ppm fluoride (as sodium fluoride) were added to one of 2 digesters, the other, containing the same substrate, serving as control. From results of 2 experiments extending over 75 days, the concentration of fluoride used did not appear to affect the digestion activities, i. e., cumulative gas production. The concentration used exceeds by at least 10 times the expected concentration of fluoride (0.5 ppm) that may be found in sludge as a result of bringing the fluoride level in water to 1 ppm.

144. Menczer, L. F. (Department of Health, Hartford, Conn.): STUDY OF NINETY-EIGHT COMMUNITIES FLUORIDATING THEIR COMMUNAL WATER SUPPLY. American Journal of Public Health 42:1414-9 (May), 1952.

In a survey, 98 of 127 communities fluoridating their water supplies in 31 states as of October 15, 1951, replied to questions as to chemicals used, how fluoridation was brought about, and how financed. None reported difficulty in obtaining chemicals. Fluoride dosage varied from 0.5 ppm for summer months in southern states to 1.4 ppm for winter months in northern states. With reference to complaints, 80% reported none; 20% reported isolated complaints which were imaginative since in almost every case they were registered between the date of announcement and actual date of inception of fluoridation.

145. New York State Departments of Health and Labor: DUST CONTROL PROCEDURES IN THE FLUORIDATION OF PUBLIC WATER SUPPLIES IN NEW YORK STATE. New York State Department of Labor, Monthly Review Division of Industrial Hygiene and Safety Standards 32:21-4 (June), 27-8 (July), 1953.

This article is a condensation of a report of a joint investigation by the departments on the effectiveness of currently available equipment and operating procedures in the fluoridation of water supplies in protecting operators from exposure to fluoride dust, fumes and vapors.

Five typical installations were studied; included were: recording of time required for the routine transfer of the fluorine chemicals, and the number of filling operations per day to determine the extent of possible exposure to dust and fumes and also the concentration of dust in the immediate vicinity of the face of the operator during the period when the chemicals were handled and the empty bag was made ready for disposal. A number of recommendations are outlined.

The compounds in general use consist of powdered or granular sodium fluoride, powdered sodium fluosilicate, granular ammonium fluosilicate, to be used only when the supply is not chlorinated, and fluosilicic acid solution. The granular form of sodium fluoride and ammonium fluosilicate may be handled without the production of any significant amount of dust. Finely powdered sodium fluosilicate and sodium fluoride cannot be used without the production of dust. Approved procedures for handling are described.

Observations at the plant where fluosilicic acid is used did not disclose the release of irritating concentrations of fumes when the acid was forced into a partly covered dilution tank. Good housekeeping must be practiced irrespective of the type of equipment or chemical used. For the full protection of the operator, it is necessary to utilize both dust prevention procedures and the use of dust respirators and rubber gloves when the material is handled; also of rubber aprons to protect clothing. As a result of these studies and experience, it has been found necessary to revise the administrative procedures previously developed by the New York State Department of Health for water fluoridation programs, and to expand the requirements as to dust control equipment to be used when powdered fluorine compounds are utilized.

146. Aaroe, W. H. (New Jersey State Department of Health): STUDIES IN UNIFORMITY OF FLUORIDE ION LEVELS IN A FLUORIDATED PUBLIC WATER SUPPLY, CITY OF RAHWAY, NEW JERSEY. Public Health News 39:359-66 (Dec.), 1958.

SUMMARY: Present equipment and engineering practice assure uniformity of the optimum fluoride concentration in public water supplies.

In order to test the uniformity of fluoride ion levels in the water supply of Rahway, N. J., fluoridated since 1952 by using sodium fluosilicate and a Wallace and Tiernan gravimetric feeder, samples were collected by the Water Department 3 times weekly from Feb. 28 to July 12, 1957, at the treatment plant and from 3 widely separated sections of the distribution grid: at dead end, at a small user and at a large user of water. In addition to fluoride, determinations were also made for pH, chlorides, and nitrates. All samples were analyzed by the State Bureau of Chemistry.

Rahway's primary source is Rahway River, the water of which is treated with the other chemicals before fluoride is added; wells serve as supplemental supply, and during the test period were chlorinated separately before being fed into the standpipe. A high precision of fluoride control was shown by the fact that 88% of the samples of delivered water at the plant were within 0.1 ppm of the average of 1.1 ppm. In spite of the complex situation by virtue of admixture of nonfluoridated well water in varying ratios, the average calculated fluoride content was 1.04 ppm, and of all distribution samples, 0.99 ppm. At the dead end, it averaged 1.02 ppm; at the small user, 0.97 ppm, and at a heavy user, 0.98 ppm, thus varying between 2 to 3% of the average. There was no evidence, therefore, of fluoride being deposited in the system to be released in highly concentrated batches. A comparison of the uniformity of controlled fluoride content with uncontrolled chlorides and nitrates showed that the latter two exhibited coefficients of variation 3.3 to 3.4 times as great as obtained for fluoride. It was concluded that confidence in the ability of present feed machines and engineering practice to provide accurate, precise fluoride levels in community water supplies is justified.

147. Maier, F. J. (Division of Dental Public Health, U. S. Public Health Service): A SYSTEM FOR FLUORIDATING INDIVIDUAL

WATER SUPPLIES. American Journal of Public Health 48:717-23 (June), 1958.

Since only about 60% of the U. S. population has access to community water supplies that can be fluoridated, other methods of securing the optimum amounts of fluoride for dental health have been developed, including topical application of fluoride solutions, bottled fluoridated water, tablets, fluoridated salt or milk, etc. The results, however, indicate that fluoridation of the existing water supplies provides the most effective dental protection. Therefore, equipment was developed for the fluoridation of private water supplies.

The system described had been applied for 2 years in 4 homes in Maryland which took water from individual wells. The commercially available feeders used were either of the solenoid- or water pressure-actuated diaphragm type. Both have functioned accurately and safely, but whatever equipment is used, its installation, maintenance, and supervision requires a service organization whose functions would have to be the immediate concern of the health department. A plan is outlined according to which households of a certain area would subscribe to individual fluoridation service at the cost of about $3.00 per month.

148. Maier, F. J. (Division of Dental Public Health, U. S. Public Health Service). PARTIAL DEFLUORIDATION OF WATER. Public Works 91:90-2 (Nov.), 1960.

Even though methods for the removal of excessive fluorides from water have been published soon after the cause of dental fluorosis was discovered, there has been lack of acceptance of these measures due probably to alleged excessive costs of treatment plants, and costs and complexity of operation. About 10 years' experience in 3 communities, however, has shown that is no longer true.

Despite the widespread use of public water supplies containing fluoride in concentrations of at least 3 times the optimum levels and the availability of 3 methods that have proved practicable, only 3 plants designed specifically for fluoride removal are now operating. Two of the methods described use either activated alumina or bone char in the form of an insoluble granular medium which removes fluoride as the water percolates through it. The medium is periodically regenerated by chemical treatment when it becomes saturated with the fluoride removed from the water. In the third method, magnesium may be added to the water in the form of dolomitic lime. It is removed, after absorbing the fluorides by passing the water through settling basins and filters and is then discarded.

The plant at Bartlett, Texas (operation by the U. S. Public Health Service was started in March, 1952), using activated alumina, is capable of treating 400 gallons of water per minute, reducing the fluoride content from 8 ppm, and more recently from 3 ppm contained in a new source of water, to an average of 1 ppm. The equipment cost $11,360 in 1951 including installation. The media cost an additional $4,000. The building, which includes space for a laboratory bench, connections to the sewer, to the wells and to the ground storage tanks and foundations for the tanks, was furnished by the city. Costs of chemicals for the 3-ppm well were $25 per million gallons, for the 8-ppm well, $40 per million gallons, all costs FOB chemical manufacturers. Activated alumina is also used at the Army plant of Camp Irwin near Barstow, California, and in several experimental home defluoridation units.

Bone char is used at Britton, South Dakota. This is the only defluoridation plant in the United States using this material. Construction of this plant was completed and operation started November 20, 1948, with a synthetic hydroxyapatite for a medium. This material was abandoned during February, 1953, because of excessive (42% per year) losses due to attrition. The cost of the equipment for the plant in 1947 was $12,245 including the media. Bone char of the type suitable for this purpose now sells for 4-1/2 cents per pound, FOB manufacturer. A complete charge of 300 cubic feet costs $540. Current chemical costs (FOB manufacturer) for regeneration amount to $53 per million gallons.

Although no plants have yet been built specifically for fluoride removal using the magnesium process, several softening plants in communities with hard-water wells incidentally remove small amounts of fluoride along with the magnesium. While the combination of softening and removal of fluoride using the same equipment and treatment chemicals would make the cost of defluoridation more economical, the initial cost of the plants and of chemical and sludge handling is much higher than for plants using a chemical regenerated medium.

The operation, control, and maintenance of defluoridation plants are no more difficult than those of conventional water treatment plants. After adequate training, employees of water systems become capable operators of the equipment required which is a collection of standard water treatment items. The cost and complexity of operation are similar to the softening, iron removal, decolorization, and clarification processes.

149. Maier, F. J. (Division of Dental Public Health, U. S. Public Health Service): ADVANCES IN THE USE OF FLUORSPAR FOR FLUORIDATION. Journal American Water Works Association 52:97-105 (Jan.), 1960.

Fluorspar, a mineral containing 85 to 98% calcium fluoride is by far the cheapest of all fluoride sources, but it had not been possible to use it in water fluoridation because of its insolubility in water. This has become possible by use of alum, a chemical routinely employed in water plants as a coagulant. In a saturated fluoride solution, the fluoride concentration is about 10% of the alum concentration; thus, saturated fluoride concentrations between 1 and 3% can be obtained by varying the concentrations of the alum between the extremes of 10% and 30%.

A dissolving tank, first installed at the Bel Air, Md., water plant in 1956, is described. It has a circular weir around the inside for collecting and removing the dissolved fluoride and alum solution, which rises through the bed of fluorspar in the bottom of the tank. A central tube is fixed in the middle of the tank to support the mixer, and a cone is attached to the bottom of the pipe. A solution feeder previously used for feeding alum solution into the raw water is so arranged that it discharges into the tube of the dissolver; the latter is charged with 300 lb. of fluorspar and the alum solution is made up by dissolving about 50 lb. of alum in 50 gal. of water, forming an alum solution of about 11% strength. By adjusting the alum feed rate, 1 ppm fluoride can be fed into the raw water with 10 ppm alum. At these ratios, the dissolver can fluoridate up to 6,000,000 gal. of water for each 100 lb. of fluorspar. Calcium sulfate, produced at the rate of 1.7 lb. per pound of fluorspar dissolved, must be removed before more fluorspar is added. The Bel Air equipment is particularly adaptable for smaller plants, delivering less than 2,300,000 gal. per day.

The design of the equipment was modified for use in larger plants, such as installed in the water utility serving Rosiclare and Elizabethtown, Ill. The fundamental changes were: (1) An existing volumetric dry feeder for alum was the source of the alum solution of which a constant portion was metered into the fluorspar dissolver. To change the fluoride dose, the alum concentration from the dry-feeder dissolving chamber was controlled by careful regulation of the amount of the entering water. A change in the quality of the raw water, requiring adjustment of the alum dose, was compensated by resetting the alum feeder and changing the amount of water flowing to the dissolving chamber to produce the same strength of alum solution as before. (2) The rate at which alum solution is introduced into the dissolving chamber was selected and fixed experimentally from observations of the hydraulic separation of fluorspar and calcium sulfate, so that the amount of calcium sulfate discharged would equal the amount formed. The sulfate discharged into the water presents no difficulties in subsequent treatment processes; in fact, by providing additional nuclei for floc formation, this is a slight advantage. (3) To facilitate the addition of fluorspar to the dissolver and to provide in it a constant concentration of dissolved solids, a volumetric dry feeder is used. The amounts of fluorspar added and dissolved and the amounts of calcium sulfate formed and discharged were equated in order to maintain the same distance between the weir and the solids blanket when the dissolver is not operating. A nomogram is used to obtain the correct water flow rate into the alum dissolver to obtain various alum and fluoride concentrations. The apparatus used is described and diagrammed. Under the conditions described, the dissolver is capable of fluoridating up to 8,000,000 gal. per day at 1 ppm.

It is believed that the apparatus could be scaled upward to accommodate the largest water plants in the country. Calculating that 1 lb. of fluorspar is required to fluoridate by this method the water consumed annually by 1 person, approximately 70,000,000 lb. of fluorspar per year would be used for water fluoridation in utilities in the United States using coagulants in their treatment plants.

150. Ingram, W. T. (New York Univ.): APPLICATION OF FLUORIDES TO WATER. Water and Sewage Works 108:183-7 (May), 1961.

The findings of extensive studies on fluoridation practices in 20 major cities of the United States (1957) as well as accumulated additional data are presented as a guide for engineers, waterplant superintendents and others concerned with the cost and technical planning of water fluoridation.

In a system using dry chemicals, the fluoridation of 1 million gallons (MG) of water to the level of 1 ppm requires 19.3 lb. of sodium fluoride (solubility 4% at 60°F.) in 58 gal. of water or 14 lb. of sodium fluosilicate (solubility 0.4% at 75°F.) in 335 gal. of water; at least 9.3 gal. of water per pound of sodium fluoride and 76 gal. per pound of sodium fluosilicate are necessary for solution so as to prevent the precipitation of calcium fluoride as crustation in the solution tank and pipelines leading to the point of application.

In most systems using liquid chemicals, fluosilicic acid is most widely used, and 3.34 gal. of the acid at 23.75% concentration are required to fluoridate 1 MG of water.

Plastic pipes (polyvinyl chloride) have been satisfactory in carrying fluoride solution. Various commercially available dry and liquid feed pumps are listed. Chemicals used are required to meet Standards of the American Water Works Association. Several operating problems are discussed.

The cost of fluoridation, including expenditures for construction and equipment, chemicals and operation and maintenance ranged in 18 cities from $0.30 per MG of water in Denver, Colo., to $2.87 in Charlotte, N. C., and averaged in 1956 $1.225 per MG or 7.9 cents per capita.

There appear to be economic advantages in lesser costs for construction and feeder equipment in acid plant installations. Depending on a number of variables, a specific installation should not cost more than $2.50 per MG annually to construct and operate, and in larger cities the cost should not be over $1.85 per million gallons.

The conclusion is drawn that no peculiar designs are required for the application of fluoride, but that the practices employed in the application of alum, lime, charcoal, and other chemicals can be adapted to the specific design of fluoride application units. Besides the choice of equipment and chemicals, the planning should include provisions for accurate dosage control, normal safeguards for handling dusty chemicals or strong acids, and good laboratory supervision.

[ABSTRACTOR'S NOTE: The 1957 studies are reported in the publication by W. T. Ingram and G. W. Moore, "Fluoridation in Major Cities of the United States," Journal American Water Works Association 51:1095-1110, 1959.

Installations were studied in 20 cities of 16 states, representing a population of 18,721,200 or 59.6% of the total population using fluoridated water in the United States. The largest of the cities was Chicago, Ill., and the smallest was Charlotte, N.C., with 185,000 inhabitants.

The following comments on fluoridation practices were among those summarized from these studies: All engineering problems can be solved adequately after due consideration of the factors involved; the mixing of the fluoride compound with water is achieved by the same principle as the addition of alum and chlorine; generally, the chemical composition of the water does not appear to affect the fluoride dosage, and the controls are adequate for securing proper fluoride dosage also in waters with a high calcium content. In no instance have prolonged periods of overdosage occurred, and the maximum plant effluent fluoride content found in this study (2.07 ppm) was reported in one city only, and for a fraction of a day. Neither the length of line, period of flow, age of pipe nor materials to which the water is exposed affect significantly the fluoride content in distribution systems. No pipeline corrosion was observed, and no feedback of fluoride ion occurred from pipe coatings, tuberculation, treatment sludges and storage-reservoir sediments. The annual cost of fluoridation ranges between 7.9 and 8.4 cents per person. Normal industrial hygiene practices are adequate to keep fluoride concentrations in the air of the workrooms at safe levels and to protect the employees handling fluorine chemicals against any health hazards. In 2 cities where the water was filtered through slow sand filters, a reduction of 0.3 ppm of natural as well as artificially added fluoride was observed; fluoride loss through rapid sand filters amounted to about 0.2 ppm. No indication was found that the fluoride accumulated on filter sands would re-enter the water system.]

151. Black, A. P. (University of Florida, Gainesville): FEASIBILITY OF WATER FLUORIDATION. Journal of the American Dental Association 65:588-94 (Nov.), 1962.

Fluoridation has presented no new or unusual problems to the superintendents and operators of the 1,236 water systems which now provide 42,183,000 persons in the United States with fluoridated water.

The chemicals used (as of the close of 1960), are sodium fluoride, sodium silicofluoride or fluosilicic acid. The purity of all compounds supplied for use in water fluoridation is rigorously controlled by exact specifications by the American Water Works Association (see Abstracts Nos. 138, 139, 140). Feeders for chemicals are either the dry feeders (volumetric and gravimetric), or solution feeders. All types can be instrumented so that the rate of feeding is varied in direct ratio to the amount of water being treated. Most plants are also equipped with automatic metering and recording instruments providing charts which may be filed for a permanent record of the fluoride chemical fed. Tables show the chemicals and feeders used according to the population served.

Storage and handling of fluoride chemicals are in accordance with precautionary practices followed in water works for many years to protect operators from inhaling the dust from other chemicals used in the treatment of water. Careful studies have shown that with proper safety devices and protective clothing, the handling and feeding of fluoride chemicals do not present an occupational hazard.

Methods are available for determining the fluoride content of water with an accuracy of ± 0.1 ppm. The amount of chemical added is that required to provide a fluoride residual within limits, depending on the annual average maximum daily air temperature for the region, as specified by the Drinking Water Standards of the Public Health Service (Abstract No. 126). No difficulty has been experienced in maintaining precisely and uniformly the desired residuals throughout the water distribution systems.

A statement of recommended policy and procedure first approved by the Board of Directors of the American Water Works Association on May 29, 1949 (see Abstract No. 137) has been reaffirmed twice, most recently in June, 1962.

152. Jordan, W. A. (Minnesota Department of Health): A SUMMARY ON MINNESOTA'S FLUORIDATION PROGRAM. North-West Dentistry 41:112-22 (Mar.-Apr.), 1962.

SUMMARY: A survey of 58 water systems showed that fluoridation can be carried out effectively at a low cost with no mechanical problems.

Sixty-seven communities of Minnesota, supplied by 58 public water supply systems, supplement the fluoride content of the drinking water to a level of 1.2 ppm. The first fluoridation programs went into operation in 1951 and most of them have done so by order of the City Council. Natural fluoride content of 1 or more ppm is found in 12 communities.

In 1960-1961, the Minnesota Department of Health, with the aid of the public health engineers and sanitarians of the 8 district offices surveyed all fluoridated water systems by questionnaire and personal contact. The results are tabulated in detail.

In summary, in 11 communities, the local health officer was given a monthly analysis of the fluoride content of the water. It has been recommended that the policy of such monthly reports be adopted and activated in all communities fluoridating drinking water, to assure constancy in fluoride levels. The adoption of new programs has varied according to district.

Sodium silicofluoride is used in 22 systems, sodium fluoride in 16, hydrofluosilicic acid in 18, and ammonium silicofluoride in one. Recent installations are favoring the use of hydrofluosilicic acid as a more convenient and simple means of providing fluoride to the water. Thirty communities reported no breaks in the continuous feeding of fluoride, but 22 systems showed minor breaks of 3 days to 2 months during total years of operation. In one system, treatment was omitted for 3 months each year during the summer. Generally, the reasons for breaks were repairs, changing wells, and the like. Minor breaks would have no effect on the benefits of the program, but discontinuing treatment yearly for 3 months might be depriving the children of the expected benefits.

Operators of 11 systems reported some minor mechanical problems, which were easily adjusted. In most cases, the interest, attitude and responsibility of the superintendent to the program were most favorable.

The cost of installation and purchase of fluoride feeders ranged from a low of $414 to a high of $32,000 (Minneapolis), with an average cost, not including Minneapolis, of $1,526.

All but 6 systems use the colorimetric comparator for checking the fluoride content of the water; in 5 systems it was checked by weight to volume, and one indicated checking with the laboratory of the Health Department.

153. Leatherman, G. H., and Ellis, J. A. (Fédération Dentaire Internationale): FLUORIDATION ROUND THE WORLD. Health Education Journal 17:131-48 (May); 196-208 (Sept.), 1959.

A survey, based on answers to a questionnaire, sent by the Secretary General of the Fédération Dentaire Internationale in 1959 to the 56 member associations, revealed the following:

Americas: The statistics as of June 1958 for fluoridation in the U. S. A. and Canada, where fluoridation is practiced most extensively, are given; the chemicals and equipment used; topical application of fluoride to teeth, and other means of supplementation of fluoride to diet are also mentioned. In Canada, fluoridation of water is the only method approved by the Canadian Dental Association. Use of an appliance to be placed on taps is not approved and sale of fluoride tablets must be only by prescription of a qualified physician or dentist. In Latin America, some method of fluoridation is used on a small scale in Brazil, Chile, Colombia, El Salvador, Mexico, Panama Canal Zone and Venezuela. Fluoride is applied topically in rural areas of Colombia, Venezuela and in Mexico City. In Guatemala City and in San José, Costa Rica, fluoridation had to be discontinued because of lack of chemicals. A study of the fluoride content of the Guatemalan water supplies showed that most waters have about half the optimum content, a few as high as 2.2 ppm. Argentina, Paraguay and Peru are planning fluoridation, and in the Dominican Republic and in Cuba it has been recommended. A survey of 17 cities of Nicaragua showed the highest content in Managua, 0.7 ppm, which in view of high temperatures is thought to be the optimum. Dental fluorosis occurs in the Argentine regions, Venezuela, Uruguay, the Bahamas and Barbados. Fluoridation has never been considered in the West Indies.

Africa: The only installation is in the Union of South Africa at Germiston, and approved in principle in Mauritius. In some regions of Kenya, the natural fluoride content in water is as high as 100 ppm, and optimum is thought to be 0.7 ppm. Research of dietary habits showed that the higher the protein content of the diet, the lower is the effect of fluoride. High-fluoride areas are also found in Tanganyika (up to 45 ppm), Cape Verde Islands, and in South-West Africa. In some fluoride-free regions it was decided to improve nutrition first because of calcium deficiency.

Western Pacific: Two towns in Australia are now fluoridating, as is Singapore; Hong Kong and Sarawak are considering it. In New Zealand, Hastings has had fluoridated water since 1953; upon recommendation of a Commission, numerous towns have approved it in principle. Fluoride tablets are available at most chemists' as an alternative.

In South-East Asia, fluoridation is not planned. India has many high-fluoride areas; optimum concentration is estimated to be 0.5 to 0.8 ppm; the use of sea salt is considered.

Eastern Mediterranean: Natural fluoride areas are in Algeria, Tunisia, Morocco, Cyprus; in Egypt, Alexandria adds fluoride to water; a survey of water supplies is planned. Lack of piped water in Iran makes fluoridation impossible; the habit of tea drinking from early age may account for the low caries incidence. Mottled enamel areas occur in Israel, and in low-fluoride areas, the small water supplies make fluoridation difficult.

Europe: There is no fluoridation in Denmark, France, Greece, Ireland, Norway, and Spain, although there is interest in some countries and planned in 1 city of Norway. Topical applications and fluoride supplementation in other forms have been introduced in Austria, Finland, Germany, Hungary, Italy, Switzerland, Yugoslavia, and fluoridation of water, experimentally or otherwise to a limited extent is found in Germany, Switzerland, Finland, Belgium, Czechoslovakia, Great Britain, Netherlands, and Sweden. Large scale examination of long-term results of the effectiveness of tooth fluoridation (method not known) is being carried out in U. S. S. R. Considerable natural fluoride is found in England, Greece, Hungary, Italy, Portugal, Spain, Sweden, Switzerland and U. S. S. R., while it occurs rarely in Czechoslovakia, Germany, Ireland and Netherlands.

In the second part of this report, the countries reviewed are classified, according to the attitude of the official health authorities toward fluoridation, as follows: A positive attitude has been adopted in Austria, Canada, Great Britain, Greece, German Democratic Republic, Hong-Kong, Republic of Ireland, New Zealand, Norway, Spain, U. S., and Yugoslavia. A fairly positive attitude in Australia, Belgium, Czechoslovakia, Northern Ireland, Italy, Switzerland, Union of South Africa; an undecided attitude in Denmark, Egypt, Finland, France, Japan, Hungary, Netherlands, Sweden; a negative approach in German Federal Republic, Indonesia, Latin America. The results of similar surveys on the opinion of the medical and the dental profession as well as of the general public in these countries demonstrate a variety of attitudes ranging from a definite pro- or contra-stand on fluoridation to a "wait and see" policy, indifference, or even complete unawareness of the problem.

In conclusion, it is suggested that some form of educational program be prepared to inform the public of the benefits to be obtained from fluoridated drinking water.

154. American Water Works Association, Task Group 2620P, Fluoridation Materials and Methods: STATUS OF FLUORIDATION IN THE UNITED STATES AND CANADA, 1960. Report presented by F. J. Maier, Chairman, et al. Journal American Water Works Association 54:559-78 (May), 1962.

The report includes the names of the 1,155 fluoridated water supply systems, serving 2,059 communities in the U.S., Puerto Rico, and Canada, as based on the 1960 census. Of these, 60 are Canadian, serving 1,361,626 persons living in 82 communities, and 1,095 civilian U.S. supplies that serve 40,417,432 people in 1,977 communities; in addition, 77 military supplies in the U.S. and Guam serve 134 bases of various types with a population of 751,980.

During 1960, fluoridation was initiated in 128 U. S. communities. In addition, over 7,300,000 people are using water that naturally contains 0.7 ppm or more of fluoride. Thus fluoridated water is used in the U. S. by over 48,000,000 people or by 36% of the population served by public water supplies.

In 1960, fluoridation was discontinued in 7 U. S. communities, and 64 referendums were held with 40 of them rejecting the measure. Since the start of fluoridation, a total of 583 referendums have been held with 352 rejecting and 231 adopting it.

In Puerto Rico, 93% of the people using public water supplies receive fluoridated water.

As to the chemicals used, during 1960, no new communities selected either ammonium silicofluoride or fluorspar, but hydrofluoric acid was used by 8 new water systems.

[EDITORIAL COMMENT: These census reports are prepared annually.]

The following abstracts, although located elsewhere, refer to the subject matter of this Section: Nos. 2, 4, 7, 13, 46, 74, 78, 79, 81 84, 85, 94, 101, 131, 132.

9. ANALYTICAL METHODS

Although awareness of the presence of fluoride in animal tissues, water, and vegetation dates back 160 years, so that methods of analysis have long been available, the earlier methods were crude and unreliable. More precise methods have been developed only since about 1933. These have been undergoing constant refinements and new techniques have been evolving. The references listed below constitute only a summary of the many publications in this field, and the most recently approved methods.

155. Cholak, J. (University of Cincinnati, O.): FLUORIDES: A CRITICAL REVIEW. II. ANALYSIS OF FLUORIDES. Journal of Occupational Medicine 1:648-54 (Dec.), 1959.

A review of the methods for the determination of fluoride in various materials, listing 1401 separate references was published recently by Elving, Horton, and Willard in "Fluorine Chemistry," edited by J. H. Simons, New York, Academic Press, Inc., 1954. Since the quantitative analysis of organic material is difficult, necessitating frequently special pretreatment and handling of the material, Cholak's review deals primarily with the status of analytical procedures used to determine trace amounts of fluorine in biological and related material.

Emphasis is placed upon precautions needed in collecting samples and their handling prior to actual analysis. In the case of vegetation, concentrations of fluoride vary in the different portions, so that judgment must be exercised in the selection of material. In the case of urine and blood, concentrations may vary depending upon time of collection (meals, duration of industrial exposure), size of sample, and other variations. Ashing procedures offer particular difficulties in that losses may occur with too high or too low temperatures. Proficiency of the analyst is an important factor particularly in the analysis of biological material. The distillation step and interferences by various ions are discussed.

In the determination of fluoride, of the various methods developed, the colorimetric are best suited for biological and related material. These methods depend upon the change of color that develops as a result of the action of the fluoride ion on colored metal-dye complexes, observed visually in a titrimetric procedure or measured instrumentally. More recently, titrations and colorimetry in aqueous media, as developed by Armstrong, are more exact than those in alcoholic solutions.

More recent efforts have been directed toward concentrating fluoride and separating it from interfering ions by steps other than distillation, and eliminating the ashing step. Ion exchange materials show promise, and enzymatic methods are being developed. Eighty-nine references are given.

156. American Public Health Association, American Water Works Association, Water Pollution Control Federation: STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER INCLUDING BOTTOM SEDIMENTS AND SLUDGES. 11th ed., New York, American Public Health Association, Inc., 1960, pp. 122-30.

The section on the determination of fluoride in water covers the procedures and apparatus used in 3 directly applicable colorimetric methods without distillation when interfering ions are not present in excess of the tolerances of the method. The concentrations and types of error of interfering substances causing 0.1 mg. per liter error at 1.0 mg. of fluoride per liter of water are tabulated. These methods are based on the reaction between fluoride and a zirconium lake and sensitive to 0.05 mg. of fluoride per liter. The visual method of Scott-Sanchis, applicable to samples containing up to 1.4 mg. of fluoride per liter, requires no special equipment or accurate time control except in certain cases; the photometric method of Megregian-Maier is applicable to samples containing 0 to 2.5 mg. of fluoride per liter, but readings must be taken exactly at 60 ± 2 min.; the photometric method of SPADNS (tentative) is limited to the range of 0 to 1.4 mg. of fluoride per liter, but it does not require a waiting period after addition of the reagent. In general, the methods are susceptible to the same interfering substances but to varying degrees. Chlorine interferes in all of the methods.

The procedures described for the elimination of interfering ions are preliminary steam distillation based on the distillation of fluosilicic acid from a solution of the sample in an acid with a higher boiling point, and the preliminary direct distillation procedure (tentative) which makes preconcentration unnecessary but requires a larger sample and a broader temperature range. Recovery of fluoride is quantitative by both procedures within the accuracy of the methods used for its measurement.

> [ABSTRACTOR'S NOTE: A notice in the Journal of the American Water Works Association 54:1212, 1962 states that "the Joint Editorial Board for the 12th Edition of Standard Methods for the Examination of Water and Wastewater has upgraded from 'Tentative' to 'Standard' the 'Preliminary Direct Distillation Procedure' for fluoride (11th edition p. 126-7 and the 'SPADNS Method' for fluoride (11th edition, p. 130-1). The board's action was based on a study of results obtained by 53 laboratories participating in a survey conducted by the Analytical Reference Service of the U.S. Public Health Service."]

157. American Water Works Association, Task Group 2620P: FURTHER STUDY OF PERMANENT COLOR COMPARATOR FOR FLUORIDES. Report presented by F. J. Maier, Chairman, et al. Journal American Water Works Association 53:989-93 (Aug.), 1961.

A color comparator for fluorides which had not given satisfactory results when first tested in 1957 was re-evaluated by each member of the original Task Group after the manufacturers (W. A. Taylor

Co., Baltimore, Md.) had made available a modified version of the testing kit.

Six laboratories examined 10 samples each with 10 readings made for each sample and additional readings by means of a technique as specified in "Standard Methods."

Although the readings varied from the "Standard Methods" results in both directions, and the error increased rapidly as the temperature was outside the range of 23 to 27°C, the modified kit should produce results approaching the standard of accuracy suggested in "Standard Methods" when the manufacturer's recommendations, with suggested changes, are followed. Additional improvements are suggested.

[ABSTRACTOR'S NOTE: The first test of Kits A and B is reported in "Study of Permanent Color Comparators for Fluorides," Journal American Water Works Association 49:417-26, 1957. On the basis of 4,000 tests on each kit, the accuracy of Kit A was generally satisfactory but could be enhanced by defining more precisely the conditions of operation, and by further improvement of results when the premixed reagent is used. Kit B, satisfactory for detecting gross feeding errors, did not produce results within the standard of accuracy defined by "Standard Methods."]

158. Bellack, E. (Division of Dental Public Health and Resources, U. S. Public Health Service): AUTOMATIC FLUORIDE DISTILLATION. Journal American Water Works Association 53:98-100 (Jan.), 1961.

The improvements in the direct distillation method (1958) described introduce automation into the distillation process by the replacement of the thermometer with a thermoregulator. Other technical refinements in the apparatus eliminate the necessity for mixing the sample and acid, and make possible the addition of the sample without dismantling the apparatus. Heat is supplied by a quartz mantle, and the entire assembly rests on a magnetic stirrer.

Precision and accuracy of the results as well as precautions are identical with those of the original method, but the uniform heating characteristics of the electric mantle minimize the danger of sulfate carry-over.

The following abstracts, although located elsewhere, refer to the subject matter of this Section: Nos. 4, 6, 7.

GLOSSARY

(Terms commonly encountered in the scientific literature of the fluorides)

absorption — physiologically, "absorption," as used herein, generally means the passage of a nutrient or substance ingested in food and water from the intestine (where food is digested) into the blood stream. (Materials may also be absorbed in the respiratory tract or (in some instances) through the skin.)

analytical data on food or tissue — the numbers may relate to dry, ashed, or wet (fresh) weight. There are large differences between these. For instance, intervertebral cartilage was reported to contain 0.007% of fluoride on a dry, fat-free basis and 0.159% on an ash basis (from Zipkin, et al., Abstract No. 56). Most foodstuffs contain a high percentage of water; for example, the fluoride content of citrus fruit which contain 80 to 90% of water, may be 0. 04 to 0. 36 ppm in the fresh state and 1. 4 to 2. 2 ppm in the dry state; the fluoride content of fish with 60 to 80% water content may vary in the fresh state from less than 0. 10 to 24, while the ashed tissue may yield 84. 5 ppm. (From Cholak, Abstract No. 14)

blood plasma — pale yellow fluid portion of the blood, constituting from 50 to 60% of the volume of whole blood, the remainder being the formed elements: red and white corpuscles, and thrombocytes or blood platelets.

blood serum — the clear liquid which separates from the blood when it is allowed to clot.

body weight of man — varies according to age and height; average weight of adults: male, 143 lb. (65 kg.); female, 126 lb. (57 kg.). (From Standard Values in Nutrition and Metabolism, Philadelphia, W. B. Saunders, 1954, p. 244)

body weight (average) of some common, full grown laboratory animals: dog (average size), 32. 85 lb. (14. 9 kg.); rabbit, 7. 72 lb. (3. 5 kg.); guinea pig, 1. 67 lb. (0. 758 kg.); rat, 0. 661 lb. (0. 300 kg.); mouse, 0.63 lb. (0.0285 kg.). (From Standard Values in Nutrition and Metabolism, Philadelphia, W. B. Saunders, 1954, p. 244)

°C. — abbreviation for degrees on the centigrade scale.

CaF_2 — empirical chemical formula for calcium fluoride.

calcium fluoride (CaF_2) — a mineral containing 51. 33% calcium and 48.67% fluorine. Molecular weight 78.08 (calcium ion = 40. 08, fluoride ion = 38).

cc. — abbreviation for cubic centimeter (now replaced largely in scientific literature by milliliter (ml.)).

centigrade — scale of degrees of temperature; to convert to degrees of Fahrenheit, multiply the number of centigrade degrees by 9/5 and add 32 to the result.

centigram — unit of weight; 1/100 (0. 01) gram (see "gram" for equivalent in ounces).

centimeter — unit of length; 1/100 (0. 01) meter; 0. 393 inch (about 1/3 inch).

cg. — abbreviation of centigram.

cm. — abbreviation for centimeter.

concentration — amount of a given substance in a stated unit. Measured as milligram per kilogram, milligram per liter, molar, parts per million, percent, etc. For examples, see under various units: "milligram," etc.

cryolite (Na_3AlF_6) — a mineral containing fluoride; typical composition is 13. 23% aluminum, 32. 71% sodium, the remainder fluoride and some impurities such as manganic oxide, magnesium oxide, and vanadic and phosphoric acids.

cryolite, synthetic — a chemical compound, sodium fluoaluminate, formula: Na_3AlF_6.

cubic centimeter — unit of volume; same as milliliter.

cubic meter — unit of volume; 1000 liters, equivalent to 1056. 7 fluid quarts or 264. 173 U. S. gallons.

cu.m., or m^3 — abbreviation for cubic meter.

curie — unit of radioactivity defined as the quantity of any radioactive nuclide in which the number of disintegrations per second is 3.7×10^{10}.

def — abbreviation for decayed-extracted-filled (deciduous) teeth.

df — abbreviation for decayed-filled (deciduous) teeth.

DF — abbreviation for decayed-filled (permanent) teeth.

DMF — abbreviation for decayed-missing-filled (permanent) teeth.

dose — a quantity of a substance administered at a given time. In animal experimentation, this is usually expressed as milligrams of substance per kilogram of body weight of animal.

elimination — the act of expulsion of material from the body in the urine or feces.

endemic — peculiar to a particular region; refers to a condition or disease which occurs more or less constantly in any locality.

excretion — the act, process or function of removal of substances or waste matter from the body, such as through the kidney into the urine, or through the intestine into feces.

F — chemical sign for fluoride (generally understood to be the ion F^-); see also "fluorine," "ion."

°F. — abbreviation for degrees Fahrenheit.

Fahrenheit — scale of degrees of temperature; see "centigrade" for conversion from degrees in centigrade to Fahrenheit; to convert from Fahrenheit to centigrade, subtract 32 from Fahrenheit temperature and multiply the remainder by 5/9.

fluoride — as used in this bibliography, refers generally to the ion, or is used as the adjective; in chemical terminology, a fluoride is a salt or ester of hydrofluoric acid containing the monovalent F^- radical.

fluoride intake of man from water containing fluoride in a concentration of 1 ppm corresponds to 1 mg. of fluoride per liter of water; equivalent to 0. 946 mg. (0. 000033, or approximately 1/30, 000 of an ounce) per quart of water. See also Abstract No. 9.

fluorine — an element of atomic number 9, and atomic weight of 19, belonging to the halogen group; reference is made to compounds of fluorine, which may also be designated as fluorides.

fluorite — see "calcium fluoride."

fluorosis — refers generally to the enamel changes caused by the prolonged daily ingestion of excessive quantities of fluoride (2 to 8 mg. or more daily) during the period of enamel calcification (the first 8 years of life); to avoid confusion, the term should be modified by "dental" as distinguished from "skeletal fluorosis," which refers to the increase in the radiopacity of bone and other abnormalities associated with the absorption of large quantities of fluoride by the skeleton.

fluorspar or fluospar (synonyms: fluorite, calcium fluoride), see "calcium fluoride."

fluosilicic acid (H_2SiF_6) — a chemical compound containing 1.40% hydrogen, 79.12% fluorine, 19.47% silicon; molecular weight 144.08 (hydrogen ion = 2.016, silicon ion = 28.06, and fluoride ion = 114.00).

food intake of man varies with age, weight, health of individual, activity, climate, etc.; average estimated total dry food, 9.8 grams per kilogram of body weight per day by male, 45 years old, average 65 kilograms weight, or 637 grams, equal to 1.4 pounds; 8.2 grams per kilogram by female, 45 years old, average 55 kilograms weight, or 451 grams, equal to 0.925 pound. (From Standard Values in Nutrition and Metabolism, Philadelphia, W. B. Saunders, 1954)

food intake of some adult laboratory animals in form of dry laboratory diet, in grams per day (liquids omitted): dog (10 kg. body weight), 250; guinea pig, 30; mouse, 3; rabbit, 60; rat, 10-20. (From Association of Food and Drug Officials of the U.S., Quarterly Bulletin 18:66, 1954)

g. — abbreviation for gram.

gallon (British, Canadian, Imperial) — equals 4 quarts (liquid, British); or 4.54596 liters.

gallon (gal.) (U.S.) — equals 0.83268 British or Imperial (Canadian) gallons; or 4 quarts (liquid); or 3.7853 liters.

grain — unit of weight; 1/7000 pound; equal to 0.0022857 ounce; or to 64.798918 milligrams.

gram — unit of weight; 1/1000 kilogram; equal to 1/300 ounce (0.035 ounce); 15.43 grains.

HF — empirical chemical formula of hydrofluoric acid or hydrogen fluoride; molecular weight, 20 (hydrogen ion = 1, fluoride ion = 19).

H_2SiF_6 — empirical chemical formula of hydrofluosilicic acid, see "fluosilicic acid."

hydrofluoric acid — a solution of hydrogen fluoride gas in water. Usually marketed in concentrations of about 47% hydrogen fluoride gas and 53% water.

ion — an electrically charged (positive or negative) atom, radical, or molecule; according to the ionic theory, electrolytes split into component ions whenever they are dissolved in water. Example: sodium fluoride splits into the sodium ion (Na^+) and fluoride ion (F^-).

kg. — abbreviation for kilogram.

kilogram — unit of weight; 1000 grams; 1 kg. is equal to 2.205 pounds or 35.274 ounces.

kilometer — unit of length; 1000 meters; 1 km. equals 0.621 mile, or 1093.61 yards.

km. — abbreviation for kilometer.

l. — abbreviation for liter.

lb. — abbreviation for pound.

liter — unit of volume or capacity; 1 l. equals 1.0567 quarts (U.S. liquid), 0.8799 quart (British); or 33.8147 fluid ounces (U.S.), 35.196 fluid ounces (British).

m. — abbreviation for meter.

M. — abbreviation for mole (molecule), molar.

metabolism of a substance (such as fluoride) in the body — the fate in the body of the organism, including transport after ingestion, inhalation or contact with the skin (if the substance penetrates the outer layers of the skin); absorption, chemical reactions, with the formation of other substances or degradation products; distribution, retention in the tissues, excretion and elimination from the body. In short, the sum of all the physical and chemical processes by which the living organism reacts with and is reacted upon by a substance, which thereby may be transformed into energy for the uses of the organism.

meter — unit of length; equivalent to 3.28 feet.

mg. — abbreviation for milligram.

microcurie — one millionth of a curie.

microgram — unit of weight; one millionth of a gram; 0.001 milligram; or 0.000000035 ounce.

micron — unit of length, one millionth of a meter; equivalent to 0.000039 inch.

milligram — unit of weight; 1/1000 of a gram; equal to 0.000035 (approximately 1/30,000) ounce, or 0.0154 (1/648) grain; 1 mg. per liter of water or per kilogram of tissue or food is equivalent to 1 ppm; 1 mg.% is the concentration of a substance expressed in mg. per 100 ml. of fluid or 100 g. of solid tissue.

milliliter — unit of volume or capacity; same as cubic centimeter; 1/1000 liter; equals 0.0338 (1/300) fluid ounce (U.S.); or 0.0352 fluid ounce (British); 0.27 dram.

millimeter — unit of length; 1/1000 meter; equals 0.039 inch.

millimole — 1/1000 of a mole (molecular weight of a material); see "molar."

ml. — abbreviation for milliliter.

mm. — abbreviation for millimeter.

mM — abbreviation for millimole.

mobilization — the act or process of removal of a substance from storage depots such as bone (in the case of fluoride), or fatty tissue.

molar concentration of a solution — weight of one molecule of a substance (in grams) per volume of solution (one liter, or 1000 ml.). Example: sodium fluoride has a molecular weight of 42; thus 1.0 M is 42 grams per liter or 42,000 ppm, of which sodium ion represents 23 grams or 23,000 ppm, and fluoride 19 grams or 19,000 ppm. Dilute solutions (such as used in enzyme studies) are usually expressed as 1.0×10^{-x}M; thus; 1×10^{-3}M F = 0.001 mole of fluoride, equivalent to 0.019 gram per liter or 19 ppm.

mole — a gram-molecule, or formula weight in grams; see "molar concentration."

molecule — the chemical combination of two or more like or unlike atoms, such as sodium fluoride (NaF).

mottled enamel — see "fluorosis."

GLOSSARY

Na_3AlF_6 — empirical chemical formula of cryolite or sodium fluoaluminate.

NaF — empirical chemical formula of sodium fluoride.

Na_2SiF_6 — empirical chemical formula of sodium fluosilicate.

ounce (solids) — unit of weight; equals 28. 35 grams.

ounce (fluid) — unit of volume or capacity; 1 U.S. ounce equals 29.57 milliliters; 1 British ounce equals 28.413 milliliters.

part per million (ppm) — a measure of proportion by weight and equivalent to a unit weight of solute per million unit weights of solution. (From American Society for Testing Materials Standards, 1958, p. 1107.) One part per million is generally considered equivalent to 1 milligram per liter, or 1 milligram of solute per kilogram of solution or substance in which it is present.

per cent (%) — 1% is equivalent to 10, 000 ppm.

pound — unit of weight; equals 0. 454 kilogram.

ppm — abbreviation for part per million.

quart (British, liquid) — unit of volume or capacity; equals 1/4 British gallon; 1. 1365 liters.

quart (U. S., liquid) — unit of volume or capacity; equals 1/4 gallon; 0. 946 liter; 32 ounces.

radioactive isotope — an unstable form of an element that spontaneously transforms itself into a more stable configuration by the emission of corpuscular or electromagnetic radiation. Radioactive isotopes of numerous elements occurring in the body, such as fluoride, iodine, may be used to "tag" the stable compound administered, and the fate of the compound in the body can thus be traced readily because the radiation may be detected by sensitive apparatus. This technique has provided a precise measurement both qualitatively and quantitatively of the course of substances taken into the body.

sign — see "symptom."

sodium fluoride (NaF) — chemical compound containing 54.75% sodium and 45.24% fluorine. Molecular weight 42 (sodium ion = 23, fluoride ion = 19).

sodium fluosilicate (Na_2SiF_6) (synonym: sodium silicofluoride) — a chemical compound containing 24. 46% sodium, 14. 92% silicon, and 60. 62% fluorine; molecular weight, 188. 05 (sodium ion = 46, silicon ion, = 28. 05, fluoride ion = 114).

symptom— a phenomenon of disease which leads to complaint by the person involved; in contrast to sign (of disease) which is objective, symptom is subjective.

syndrome— a group of symptoms and signs which, considered together, characterize a disease or lesion.

water intake of man — 1. 2 to 1. 6 liters daily in a temperate climate, plus water in tea, coffee, food, etc. (McClure, National Institute of Health Bulletin 172, 1939). Adult, average 2. 5 liters per day (including fluid contained in food); children, see Abstract No. 96.

weight — see "body weight."

μ — symbol for micron.

μc. — abbreviation for microcurie.

μg. or γ — abbreviation for microgram.

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As most of the chapters and articles listed in books (Abstracts Nos. 1, 2, 4, 5, 8) are not abstracted, certain significant topics contained in them have been entered into the index. For identification, the name of the principal author has been placed in parentheses following the number. The entries include material contained in editorial comments.

"See" references, if capitalized, indicate entries under the main alphabetical sequence; those in lower case, enclosed in quotation marks, refer to entries under the capitalized heading.

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